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# ACTIVITIES OF THE PLANT PEST CONTROL DIVISION



## FOREWORD

The American public needs protection against the establishment of foreign plant pests and outbreaks of native pests, which threaten our resources and increase the cost of production. The Congress has recognized this need and provided funds to carry on protective programs. By taking action as directed and initiating necessary procedures, the Department of Agriculture is performing a vital function deemed by Congress to be in the public interest. The prompt detection of new pests and early remedial actions often avoid the need for repeated annual control efforts over wide geographical areas.

The United States Department of Agriculture has broad authority to join interested States, organizations, or individuals in programs to suppress or eradicate agricultural pests. This authority has been assigned to the Plant Pest Control Division of the Agricultural Research Service. Emphasis has been placed on pests of foreign origin and those native pests capable of sudden outbreaks which are beyond the scope of the individual grower to handle. All organized action programs to confine, suppress or eradicate plant pests are cooperative with the States concerned.

This report is presented as a summary of the Plant Pest Control Division's activities, its functions, and background information on programs in which the U.S. Department of Agriculture and the States are actively engaged.

## LEGISLATIVE AUTHORITY

The Plant Pest Control Division operates under the authority granted the United States Department of Agriculture in the following general and specific Federal legislation:

- The Federal Plant Pest Act (7 USC 150aa - 150 ii).
- The Plant Quarantine Act of 1912 (7 USC 151 - 167).
- The Incipient and Emergency Outbreak Resolution of 1938 (7 USC 148 - 148e).
- The Mexican Border Act of 1942 (7 USC 149).
- The Department of Agriculture Organic Act of 1944 (7 USC 147a).
- The Golden Nematode Act of 1948 (7 USC 150 - 150g).
- The Halogeton Glomeratus Control Act of 1952 (7 USC 1651 - 1656).

# PLANT PEST CONTROL DIVISION

## OFFICE OF THE DIVISION DIRECTOR

Program Development and Direction  
Cooperative Relationships  
Program Analysis and Evaluation  
Staff Development  
Administrative Management  
Regional Insect Control Project  
(Foreign Technical Programs)

## PROGRAM DEVELOPMENT AND SERVICES STAFF

- Provides technical direction in —
- Control Operations planning
  - Methods and Operations planning
  - Regulatory Operations planning
  - Survey Operations planning

## PLANT PEST CONTROL REGIONAL OFFICES\*

Central  
Minneapolis, Minn.

Eastern  
Moorestown, N. J.

Southern  
Gulfport, Miss.

Western  
Oakland, Calif.

Mexico  
Monterrey, N.L. Mexico

\*Program Planning (Survey Operations, Methods Improvement, Regulatory Operations, and Control Operations)  
Program Direction and Review  
Cooperative Relations

## Plant Pest Control State Offices

Administers regulatory, control, eradication and survey activities in cooperation with State(s) assigned.

## Plant Pest Control District Offices

Provides technical guidance on all activities within an assigned district.

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# ACTIVITIES OF

## Plant Pest Control Division

### SURVEY AND DETECTION OPERATIONS

Surveys when related to insects constitute an intelligence service that provides the entomologist, plant quarantine official, farmer, rancher, county agent, and the insecticide industry with essential information regarding economic insects. The value of insect surveys as a basis for the intelligent control of insect pests has long been recognized. Surveys of various kinds are utilized for research, detection, control, or quarantine purposes and are conducted each year by many agencies--State, Federal, and industry. All lead to a common goal--to obtain a better knowledge of the occurrence, distribution, abundance, and extent of damage caused by the economic insect pests that attack or threaten our agricultural crops, livestock, forest, and man.

In the Plant Pest Control (PPC) Division surveys fall into two broad categories: (1) The cooperative economic insect survey program wherein numerous interested agricultural workers provide insect information for release at the State and Federal level, and (2) surveys conducted in connection with the Division's cooperative control programs.

The cooperative insect survey program, a State-Federal undertaking to determine and report the abundance of economic insects and certain related plant pests of economic importance, was organized first in 1921 then reorganized in the Division on its present basis in 1952. National in scope, it is dependent upon the full cooperation of all of the State agricultural agencies in the 50

States. In addition to general insect survey operations and special service surveys, emphasis is placed on the early detection of insects not known to occur in the United States. The program brings together important economic insect distribution information, gathered by trained entomologists and capable observers to accomplish the following objectives:

- To assist farmers to more adequately protect their crops from insect attack.
- To supply current information on insect activity to agricultural workers.
- To aid and assure more prompt detection of newly introduced insect pests.
- To develop workable insect pest forecasting service.
- To estimate losses by insects.
- To aid in determining where insecticide supplies and equipment are needed.
- To develop nationwide uniformity in reporting insect conditions.
- To maintain records on occurrences of domestic and foreign economic insects.
- To provide a nationwide organization to guard against intentional introduction of plant pests.

Among the agencies whose employees provide assistance are the Extension Service, the Experiment Stations, State regulatory agencies, Plant Pest Control Division employees, other Federal agencies, commercial organizations, and many allied agricultural workers. Some of the State programs



N-18059

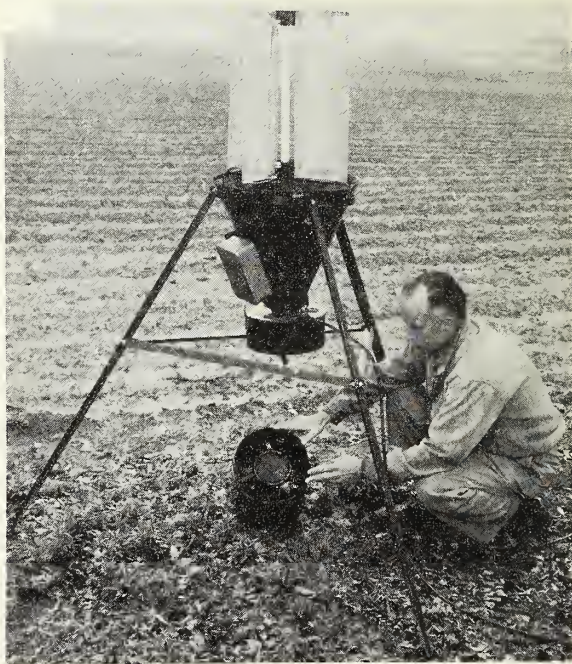
Thousands of traps like this are being used in Florida to protect our citrus industry against the Mediterranean fruit fly.

operate entirely on a voluntary reporting basis, while others employ survey entomologists. All information is made available to cooperating agencies at the State level before it is released nationally. Since 1959, State regulatory agencies, plant boards, and the Plant Pest Control Division have encouraged an accelerated insect detection program within the Nation's borders by utilizing the framework of the existing survey organization. To strengthen the detection effort, every qualified person was encouraged to participate and insect identification services were improved. Important advisory guidance has been supplied by a standing committee on Insect Surveys and Losses appointed by the Entomological Society of America. Visual aids and literature have been developed to promote the program.

Survey entomologists are jointly financed by the Federal Government and State agricultural agencies under a cooperative agreement. They are employees of the cooperator and are responsible for enlisting the assist-

ance of all available facilities for reporting seasonal insect conditions and the detection of any newly introduced economic pest of either domestic or foreign origin. In addition to encouraging voluntary participation in the overall cooperative survey program, they make and report field observations with emphasis on the arthropod pests of major field crops, vegetables, ornamentals, greenhouses, livestock, stored products, man and his environment, and forests, with special attention to migratory pests. They submit weekly reports to the State survey coordinators, and may assist with the preparation of the weekly report.

The weekly Cooperative Economic Insect Report is the approved publication for the distribution of information supplied by all cooperators. In addition it carries all information relating to general insect surveys, special situation surveys, and surveys specifically related to plant pest control, regu-



N-14848

Moth catches in light traps placed in strategic places in several Southern States tell what may be expected from such migrating pests as armyworm, corn earworm, fall armyworm, and tobacco hornworm.

latory, and eradication activities. As an aid to the detection program, a series of informative writeups on "Insects Not Known to Occur in the United States" has been developed and is published at intervals in the weekly report. Also included are insect distribution maps, loss figures, and other items of interest relating to insects. The report is made available to personnel and establishments concerned with insect conditions in each of the 50 States and numerous foreign countries.

In the Plant Pest Control Division the Survey and Detection Operations unit is

responsible for planning, developing, and formulating directives and guidelines for the operational program surveys essential to more than 20 plant pest control, eradication, and regulatory programs. It assists with the planning, develops and coordinates operational program survey activities between regions, and furnishes survey data needed for division program planning and operation. It provides technical guidance to the regions and other official cooperating agencies in program survey work and serves as advisor on survey techniques and on matters concerning special and service surveys.



BN-8674

Cotton gin trash is screened through this machine and inspected for pink bollworm larvae.

## REGULATORY OPERATIONS

The Plant Quarantine Act of 1912, as amended, authorizes and directs the Secretary of Agriculture to establish and maintain quarantine districts for plant diseases and insect pests, and to regulate the introduction and interstate movement of fruits, plants, vegetables, and other pest-carrying

materials. This 1912 Act provided the Secretary with the first Federal authority for quarantines for the protection of American agriculture. These authorities and responsibilities, insofar as they apply to interstate traffic, have been delegated to the Agricultural Research Service.



BN-16268

Insecticides are incorporated into the soil as a prerequisite to the certification of many types of nursery stock from regulated areas.



N-38182

Equipment is cleaned of all hazardous material after it has been operated in infested areas.



N-42235

To prevent long distance spread of insects, interior of airplanes is treated with a micronized dust.

The Plant Quarantine Act does not prohibit the individual States, districts, and territories from enacting plant quarantines and regulations to prohibit or restrict the interstate movement of plant pests not under Federal quarantine regulations. However, while a State could protect itself by quarantining against pestiferous material from other States so far as shipments by freight or express were concerned, the mails left an avenue for entry and distribution without inspection. The Terminal-Inspection Act of 1915, closed this loophole by allowing the Secretary to submit a list of approved plants, subject to State quarantine, to the Postmaster General, who would accept such plants for shipment by mail to the proper State official at the nearest place where State inspection was maintained. Plants or plant products found to be free from injurious pests could be forwarded; those found infested should be treated, destroyed or returned to sender.

The Plant Quarantine Act gives the Secretary authority to stop and inspect, search, and examine a person, vehicle, receptacle, boat, ship, or vessel, without warrant, and to seize, destroy, or otherwise dispose of any nursery stock, plant products, or other articles found to be moving or to have been moved in interstate commerce or to have been brought into the United States in violation of the Act or of a quarantine or order. Under this authority a transit inspection system was begun in 1921 in order to determine that provisions of the Act were being met. Transit inspectors are stationed at strategically located distribution centers, where it is possible to make spot checks and to determine the efficiency of the Federal quarantine procedures. This system of inspection augments plant pest quarantine and control programs.

The Secretary's position was clarified and strengthened further by the Department of Agriculture Organic Act of 1944 and the Federal Plant Pest Act of 1957. He may now enter into agreements with political subdivisions, farmers' associations, and others to carry out operations or measures to eradicate, suppress, control, or to prevent or retard the spread of insect pests, plant

diseases, and nematodes. These later Acts also gave the Secretary authority to cooperate with the Government of Mexico in the eradication and prevention of spread of such pests as the Mexican fruit fly, citrus blackfly, and pink bollworm.

At present, every State of the United States, except Alaska and Hawaii, is covered by one or more of the 13 Federal domestic quarantines now in effect, thus assuring the American public that their food and fiber crops will receive protection from these dangerous plant pests.

In the last half century many progressive changes in attitude, philosophy, and procedure have been effected in plant quarantine. The principles of plant quarantines were developed by a National Plant Board Committee consisting of Dr. S. B. Fracker, Mr. Walter A. McCubbin and Dr. W. C. O'Kane. Published in the Journal of Economic Entomology of June 1932, these principles have guided Federal and State plant quarantine policy for over 30 years. Attitudes toward domestic quarantines have changed with better understanding by shippers of objectives to be attained. Achieving quarantine compliance has replaced quarantine enforcement. Imposing of restrictions on shippers and carriers is now held to a minimum consistent with the objective of preventing pest spread.

Continuous effort is maintained to attain uniformity of quarantines and administrative instructions insofar as the biology and habits of the various pests will permit. Most of the Federal domestic quarantines promulgated

in recent years have four uniform bases for issuance of certificates and permits. These four points are: (1) When, in the judgment of the inspector, they have not been exposed to infestation, (2) when, they have been examined by an inspector and found to be free of infestations, (3) when they have been treated under the observation of any inspector and in accordance with methods selected by him from administratively authorized procedures known to be effective under the conditions in which applied, and (4) when grown, produced, manufactured, stored, or handled in such manner that, in the judgment of the inspector, no infestation would be transmitted thereby.

Following a critical review of the forms used for certification purposes three standard certificates were adopted, eliminating many nonstandard ones previously used. A few special types of certification require specific variations from these. Many procedures for growing, harvesting, handling, and for storage of regulated products now replace treatments and result in less cost to owners and shippers.

Many examples indicate that quarantine procedures have been effective in preventing or slowing the spread of important pests. The pink bollworm and Japanese beetle are both limited to a fraction of their potential range after more than 40 years in this country; witchweed and golden nematode have not spread beyond the general area where they were first found; and the white-fringed beetle has not become widespread over the Southern States.



BN-14573

At times it is necessary to fumigate an entire farmyard to remove any hazard of spread.

## Domestic Quarantines

Federal domestic plant quarantines.--The following is a list of Federal domestic plant quarantines arranged in order of the date they became effective. The tabulation also includes the present number of each quarantine and, where applicable, the date revoked and their former number or numbers. (This list does not include the so-called territorial quarantines.)

Present plant quarantine number	Pest	Date effective	Date revoked	Former plant quarantine number(s)
45	Gypsy moth and brown-tail moth	11-25-12	-----	4, 10, 17, 22, 25, 27, 33
6	Date-palm scale insect	3-24-13	7-1-36	-----
14	Powdery scab of potato	8-1-14	9-1-15	-----
18	Powdery scab of potato	11-14-14	9-1-15	-----
63	White-pine blister rust	6-1-17	-----	26, 54
43	European corn borer	10-1-18	7-15-32	36
38	Black stem rust	5-1-19	-----	-----
48	Japanese beetle	6-1-19	-----	35, 40
52	Pink bollworm	8-1-20	-----	46
50	Mexican bean beetle	5-1-21	7-23-21	-----
53	Satin moth	1-1-22	11-21-36	-----
61	Thurberia weevil	7-15-26	4-18-52	-----
62	Narcissus bulb	7-15-26	4-1-35	-----
64	Mexican fruitfly	8-15-27	-----	-----
65	Woodgate rust	11-1-28	7-31-39	-----
66	Asiatic beetle and Asiatic garden beetle	3-15-29	3-1-30	-----
68	Mediterranean fruit fly	5-1-29	11-15-30	-----
67	Phony peach disease	6-1-29	3-1-33	-----
71	Dutch elm disease	2-25-35	5-1-47	-----
72	White-fringed beetle	1-15-39	-----	-----
76	Khapra beetle	2-21-55	-----	-----
77	European chafer	9-1-55	-----	-----
78	Mediterranean fruit fly	5-16-56	-----	-----
79	Soybean cyst nematode	7-26-57	-----	-----
80	Witchweed	9-6-57	-----	-----
81	Imported fire ant	5-6-58	-----	-----

## CONTROL OPERATIONS

The Plant Pest Control Division administers 22 cooperative Federal-State programs for the eradication, suppression, or control of insects, plant diseases, and nematodes. From 2-1/2 to 5 million acres are treated annually. Aircraft are used for applying control materials on more than one-half the treated acres. Ground equipment, both powered and hand-operated, is used for the other treatments.

All cooperative control or eradication programs are preceded by long and careful preparation. Each plant pest control problem is analyzed to determine the plan of attack, and consideration is given to the total impact of the program. State, Federal, and other agencies take part in determining the need for the work, and the safeguards to be established to protect the health of people, domestic animals, crops, wildlife, and other

values involved. Only when it is shown that control is needed, and that all necessary safety precautions can be met, and when plans are approved by the cooperating agencies, is a program undertaken. The Federal Pest Control Review Board reviews and approves programs in which the Plant Pest Control Division participates.

Many complex problems are involved in the various control programs associated with the Plant Pest Control Division. The variety of pests involves the use of many insecticides, herbicides, and fumigants for their control. Attractants, baits, and lures are used to enhance or to reduce the amounts of chemicals that might otherwise be required to achieve control.

Of equal importance is the equipment required for applying the materials used



N-33901

High-clearance sprayer used for witchweed control in growing corn.



N-33906

Hand-sprayers are used for witchweed control in fields not accessible to high-clearance power equipment.

in plant pest control operations. Aircraft have proven to be the most efficient for the dispersal of sprays, granular insecticides, and dust. Each year the Division contracts through private operators for about 150 aircraft of various categories to apply insecticides. The Division owns 7 aircraft, used primarily for supervising contracted aerial control applications.

The Division owns and operates more than 200 pieces of specialized equipment of various types and designs. Specialized power-operated ground equipment, not commercially available through contract, is owned by the Division to distribute certain pesticides. Tractor-drawn equipment is needed for injecting fumigants into the soil. Jeep-mounted equipment is used for the application of soil and surface treatments and foliage sprays. Until recently high-clearance spray equipment was owned and operated by the Division for applying sprays in the control of witch-

weed in fields of growing corn. In addition hand-operated equipment is used for applying most of these chemicals in areas not accessible with power equipment. In operations for the control of wild cotton in the Florida Everglades, and the eradication of wild morning glories--hosts of the sweetpotato weevil--15 boats of various classes are utilized. To coordinate the many and varied control program activities, some 290 radios are used. For transportation of personnel, materials, and supplies, the Division operates 1,300 motor vehicles of various classes.

Each pest to be controlled requires the knowledge and use of one or more of the known control methods. These methods include chemical, cultural, mechanical and physical, biological procedures, and use of resistant plants. When climatic factors or other acts of nature affect pests, programs are adjusted to take advantage of the natural control that has occurred.

## Chemical Control

The Division depends upon chemical control procedures to conduct preventive or remedial operations. Chemicals used in pest control are selected carefully because of the many factors to be considered, including adverse action on plants or animals, cost of formulated chemicals, and nature and degree of persistence of residues. Secondary, but vitally important, is the ease of application.

Insecticides, herbicides, fumigants, attractants, and repellents are used in the

control of insects and diseases. These chemicals are toxic materials and destroy the insect or disease organism on which they are used. They act as stomach and contact poisons when used as sprays, dusts, or dips, and fumigants when used as a gas. Attractants are used in poisoned baits and sprays to attract insects to these materials, or to lure insects into traps. Chemical control provides immediate protection to host crops and has proven to be an effective means of controlling agricultural pests.



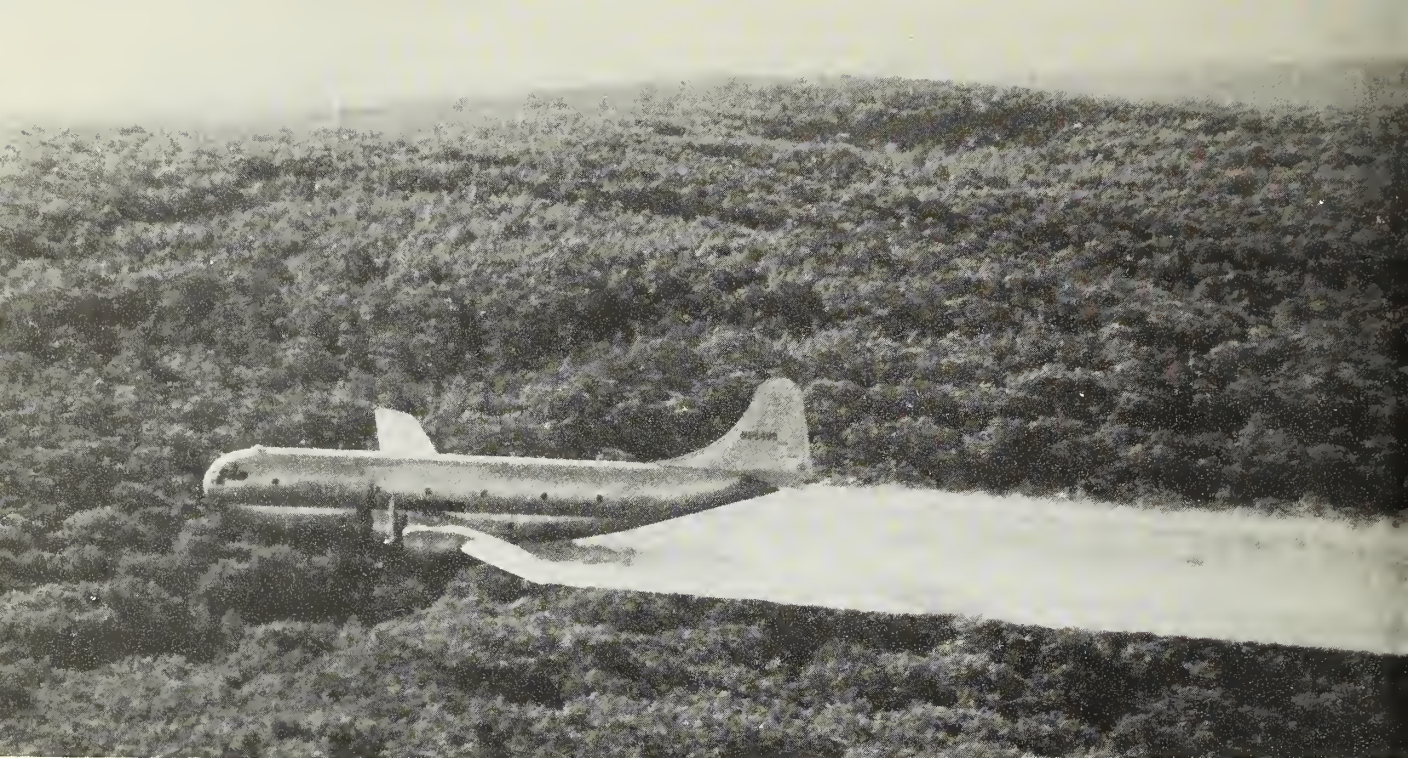
BN-13453

Loading aircraft with granular insecticide.

## Cultural Control

Farmers are encouraged to perform or time their farm operations in such a manner as to destroy insects and diseases or to prevent their injury to crops. These procedures have been effective in controlling certain pests. Rotation of crops, removing land from the production of host crops, and fal-

lowing have reduced populations of certain pests, particularly nematodes. Catch crops and trap crops might be used under certain conditions. Catch crops were used effectively for several years on the witchweed control program. Delayed planting and designation of plowup dates after harvest have given effective control of pink bollworm populations.



H-31030

Converted Stratocruiser spraying a 500-foot swath of liquid insecticide for gypsy moth control.

## Mechanical and Physical Control

The destruction of insects by mechanical and physical means, although generally costly in time and labor, has been necessary in the past to control pests. The destruction of insects or their egg masses by hand and the building of physical barriers have been effective against such pests as the gypsy moth in local areas. Deep furrows and low sheet metal fences have been used to protect crops from chinch bugs and Mormon crickets. Mechanical control procedures are still an important factor in the Division's programs against the barberry, wild cotton, phony peach, and peach mosaic.

## Biological Control

The Division encourages the development of biological control agents and is using parasites and predators to effectively control the citrus blackfly in the Republic of Mexico.

Parasitic wasps are used to keep blackfly populations to a low level. On the gypsy moth program field tests using Bacillus thuringiensis Berliner are showing promise of being effective against this serious forest pest. Homeowners are encouraged to use commercial preparations of milky disease spores against the Japanese beetle.

## Resistant Crops

Farmers, entomologists, nematologists, pathologists, and agronomists for many years have been seeking varieties of crops that are resistant to insect pests and diseases. The search for resistance and the breeding of resistance into desirable varieties have led to the discovery of a resistant variety of soybeans to the soybean cyst nematode and wheats to stem rust. And progress is being made to develop a potato resistant to the golden nematode.

# METHODS IMPROVEMENT OPERATIONS

The mission of Methods Improvement Operations (MIO) is to improve field operations on all Plant Pest Control Division programs. This is accomplished through six activities.

## 1. Liaison with Research Agencies

The Methods Improvement staff is responsible for representing the Division with respect to preliminary negotiations with public and private research agencies involving three principal objectives. First, to obtain the latest research information applicable to Division programs; second, request assistance in providing technical supervision on methods improvement investigations; and third, to encourage research agencies to include in their programs types of research urgently needed by the Division. Aside from industry and State research groups principal liaison is with the Divisions of Entomology

Research, Crops Research, and Agricultural Engineering Research of the Agricultural Research Service; the Market Quality Research Division of Agricultural Marketing Service; and the Forest Insect Research Division of the Forest Service.

The Methods Improvement staff maintains records of research accomplishments that are related to Division programs.

## 2. Field Tests and Evaluation of New Pesticides

Many of the cooperative programs result from the introduction of pests new to the United States. In most instances a backlog of research data is not available to support a control or eradication program. Even when basic laboratory research is available, its implementation on large-scale field operations requires intermediate field tests by

Experimental plots near Wilmington, North Carolina, where various soil fumigants and crop rotations have been tested for the control of the soybean cyst nematode.

BN-13401



the Methods Improvement staff using large dispersal and formulation equipment to establish guidelines. Such tests involve development of methods and techniques for formulating large quantities of material in the field, developing or modifying dispersal equipment for use with aircraft and large capacity ground equipment, and devices to facilitate survey and detection work.

### **3. Development of Improved Facilities and Techniques for Quarantine Treatments, Control, and Survey Operations**

Commodities originating in quarantine-regulated areas and transported to points outside such areas require specific treatments before they can be certified for movement. Methods Improvement personnel must continuously evaluate current and new treatments to meet the needs and requirements for the enforcement of quarantine regulations. Special attention is directed to (1) insect resistance to insecticides, (2) undesirable residues, and (3) the increased number of pesticides being developed by industry. It has been necessary to substitute soil bioassays developed by research to replace chemical analyses of multiple pesticide-treated soils on some programs. Fumigation chemicals for soil

and commodity treatments are altered as the need requires and the selection or adaptation of equipment for applying them are evaluated continually.

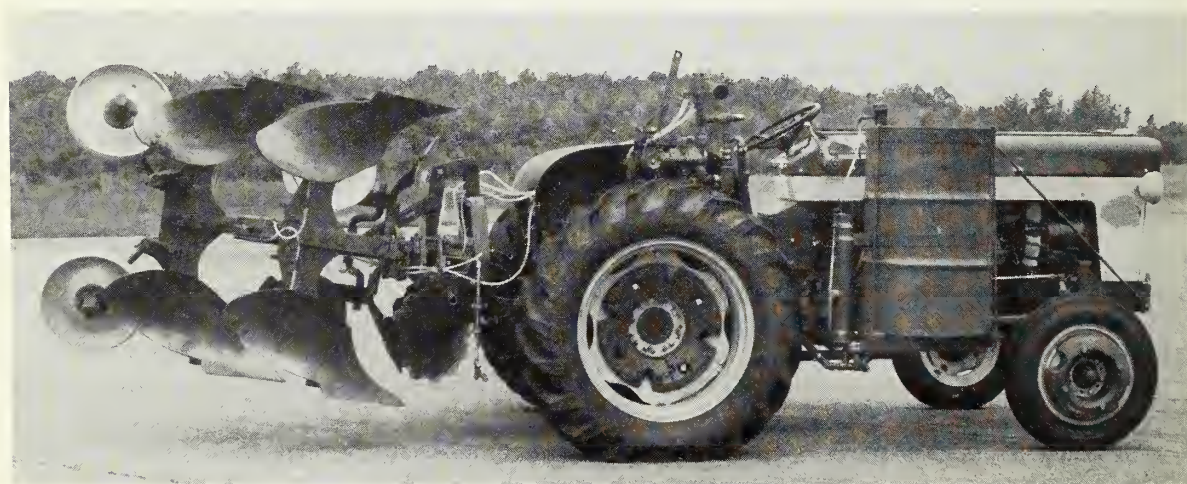
In the field of control operations modification of formulations, the selection of alternate pesticides for increased efficiency or prevention of undesirable residues and damage to wildlife are regularly under review. Recommendations for changes are made after the consideration and concurrence of the appropriate research agency.

In the field of survey and detection operations, in cooperation with appropriate research agencies, the use of sex and chemical attractants, toxicant-attractant traps, and light traps are under continuous study and evaluation. Aerial surveys for disease symptoms and defoliation, on certain programs that lend themselves to this method of survey, are conducted annually by Methods Improvement personnel.

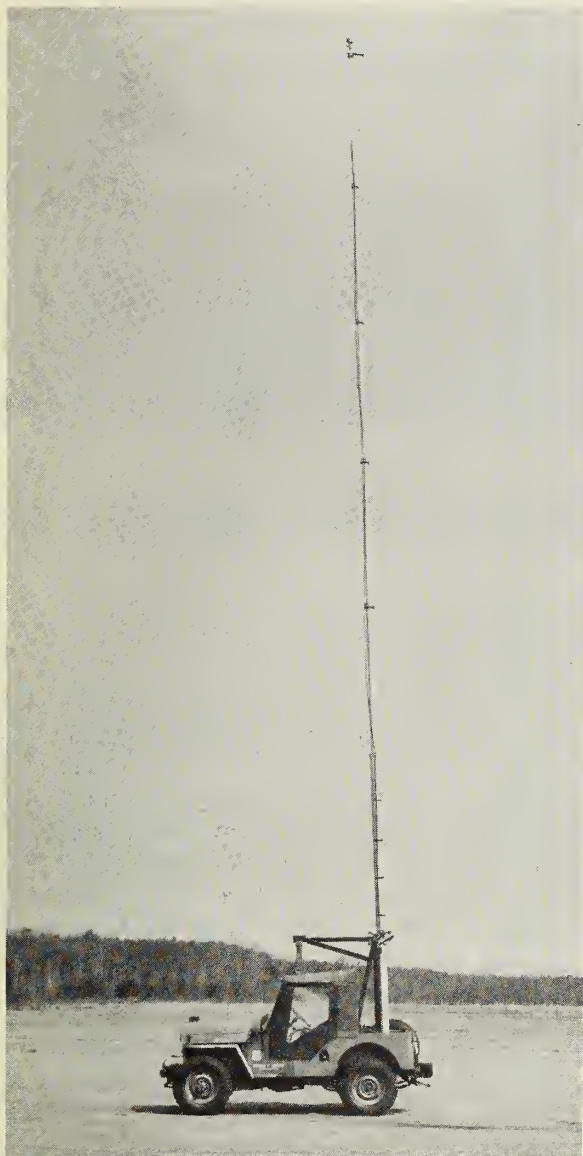
### **4. Development and Modification of Special Purpose Equipment**

A majority of PPC programs involves the control or eradication of pests that infest limited areas. For this reason industry is reluctant to invest in the development of the specialized equipment required, since assurance

A two-way plow, equipped for the application of soil fumigants by Methods Improvement Operations, places the fumigant in the plow furrow where it is immediately covered.



cannot be given that it would have widespread use. It has, therefore, become necessary to modify or adapt standard equipment to meet special requirements. Modification of aircraft dispersal equipment is an important Methods Improvement activity. Practically all contract aircraft require modification of their dispersal equipment to meet PPC stand-



Telescoping mast for the guidance of aircraft pilots in large area treatments on the imported fire ant program - one example of improvements made in equipment.

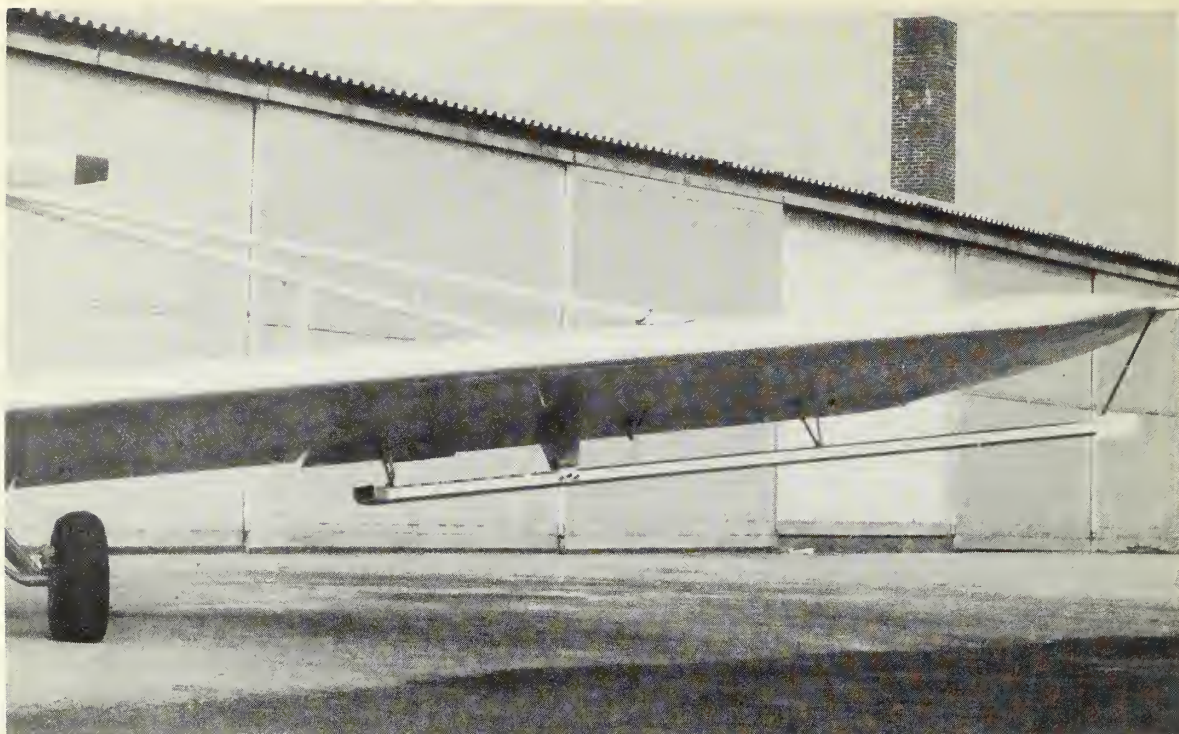
ards of uniform distribution. MIO personnel have been helpful in advising contractors on changes required to meet standards.

## **5. Technical Supervision of Aerial Applications:**

On almost one-half of its programs the PPC Division utilizes aircraft, employed under contract, for the application of pesticides. The Methods Improvement staff prepares specifications for the different types of aircraft and dispersal equipment and specifies minimum qualifications for pilots. The staff also includes highly trained pilots, utilizing Division aircraft, for assisting with the initial phases of each program, briefing contractors on the pesticides used, the areas to be treated, the direction of flight lines, calibration of aircraft, and the determination of effective swath widths. These pilots also advise the contractors on modification of dispersal equipment necessary to enable them to meet the standards required. In addition these pilots participate in planning sessions with the Control Operations staff and field supervisors to select suitable airstrips, determine the type and capacity of aircraft most suitable for the area and pest involved, and other matters required for the issuance of invitations to bid. After a program starts Methods Improvement pilots observe the performance of contract pilots and recommend the release of those not satisfactory.

## **6. Dissemination of Information for the Training and Guidance of Division Employees and the Public**

It is axiomatic that the better informed and trained an employee is the less supervision he will require and the better job he will do. Methods Improvement specialists, therefore, through the preparation and distribution of reference material and personal contact, attempt to keep employees informed of the latest developments in the handling and use of pesticides, as well as the techniques and equipment employed in applying



The swath width was doubled by releasing material from the small hopper under the wing tip through the horizontal tube where it is forced outward by ram air.

them. Information of general interest is made available to the public in meetings and through the issuance of bulletins.

For the purpose of modifying, constructing, and testing special purpose equipment a shop, staffed by equipment specialists and mechanics, is maintained at the Agricultural Research Center, Beltsville, Md. The work at this location is supplemented by several shops in the field where specialized work, indigenous to local pest control problems, is performed. The Beltsville facility also is headquarters for all Division aircraft and

provides for the servicing of them and the testing and improving of various guidance and application devices.

For programs requiring a considerable extension of research findings, Methods Improvement laboratories are established within the area of program operations. These laboratories are staffed by scientists, who work under the technical guidance of research personnel, in developing improved chemicals, biological agents, and techniques applicable to the solution of field problems.

## PROGRAM APPRAISAL

### Why

To assure that all work is done in the most effective and economical manner, the Division provides for continuing program appraisal. By a systematic review of activi-

ties in all phases of the many and varied programs, Division management expects to attain the highest standards of operational performance through constructive criticism and the encouragement of helpful suggestions.

## What

Program appraisal involves a detail review and study of all phases of individual programs including cooperative relationships with the States and other agencies. Personnel assigned to this function work independently of the operations staff and report directly to top management.

The principal objective is the continuing improvement of operations and cooperative relationships and increasing effectiveness in accomplishing the desired results at lower costs.

## How

Program evaluations are made by accumulating information on individual programs through on-site inspection, digesting and evaluating the facts and impressions gained,

and reporting a summary of findings to the Director with recommendations for needed action. The program studies include a review of background information relating to objectives, a digest of work plans, appraisal of field operations and techniques, and interviews with supervisors and operating personnel of the Division and of the cooperating State and local agencies. The appraisals are intended not only to uncover weaknesses in program operations but also to discover instances of improved techniques, which will be useful in other areas or on other programs.

Some of the advantages of this system of self appraisal are that it provides a continuing source of information to top management, it keeps field personnel alert to the continuing interest of management in good operations and gives them a sounding board on which to try out suggestions they may have for improvement.

## CAREER OPPORTUNITIES IN PLANT PEST CONTROL AND REGULATORY WORK

The Plant Pest Control Division offers a wide range of opportunities for careers in the public service. The Division's work includes a variety of programs extending into every State. The day-to-day activities involve the supervision of control and eradication procedures for introduced and native pests; surveys to detect and delimit infestations of insects, nematodes, and plant disease conditions; and enforcement of domestic plant quarantine regulations.

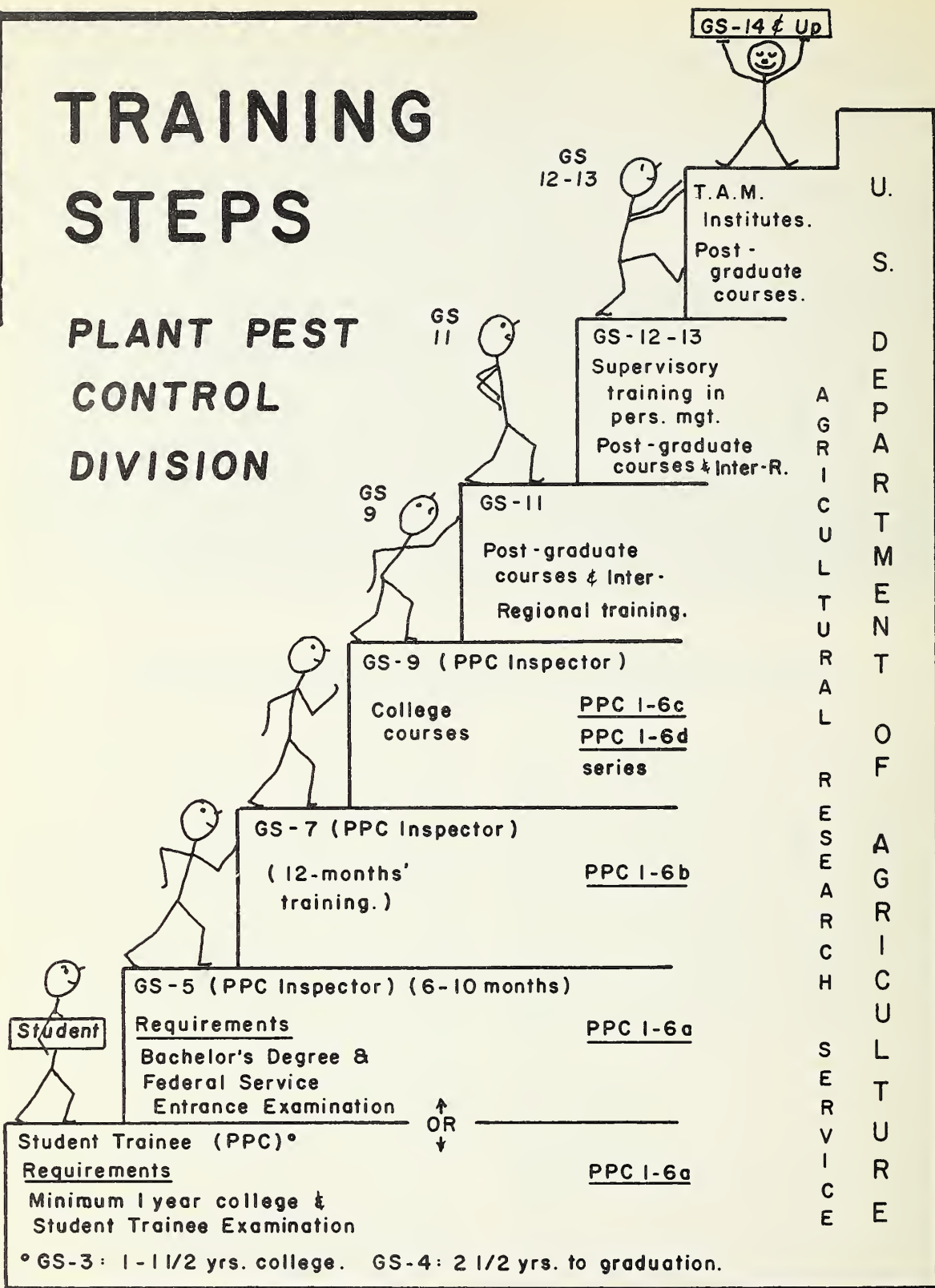
The Plant Pest Control inspector has a major role in the Division organization. He is a key field employee who is in contact with the public at the grass roots level. He is the Division's representative who works with the farmer, the urbanite, and with many industry people. The work of the PPC inspector and those he supervises determines success or failure in accomplishing work program objectives.

### Opportunities

Although appointments to the Plant Pest Control Inspector position are generally made at the GS-5 level, with some at the GS-7 level, the position is basically GS-9. This rating is attained through formalized on-the-job training given by supervisory personnel who are well versed in professional techniques, policies, and procedures. The GS-5 employee is introduced to plant pest control through a 6-month on-the-job intensified training program. If he satisfactorily completes his course, he is then promoted to GS-7. During the initial 6 months at this new grade, his performance is critically observed to ascertain whether or not the capabilities, the initiative, and performance warrant his retention in the service. When retention is recommended, additional training and instructions are provided but it is now

# TRAINING STEPS

## PLANT PEST CONTROL DIVISION



coupled with independent operation to prepare the employee for GS-9 responsibility. With the satisfactory completion of 1 year's training at this GS-7 level, the employee is then promoted to GS-9.

Promotions beyond this level are made as vacancies occur and depend upon individual performance which includes willingness to assume responsibility, initiative, application of knowledge to the needs of the program, efficiency and effectiveness of program operations in a particular work assignment, and an obvious potential to handle more responsible assignments. Promotability is measured by an annual evaluation of performance in accordance with an approved Civil Service promotion plan. All qualified individuals, nationwide, are given consideration for the filling of vacancies above the GS-9 level.

Employees who show real promise are selected for interregional training which affords them the opportunity to broaden their knowledge of Division programs. Supervisory ability and leadership are developed and strengthened through Supervisory Training programs. Professional techniques are enhanced and broadened through college attendance or completion of additional course work authorized under the Training Act. The career development of a promising employee is of the utmost importance and the Division takes advantage of all the avenues and opportunities provided by legislation.

Initial assignments are available throughout the United States to new employees and opportunities for transfer to several locations in Mexico are available to Division employees who meet specific language qualifications.

Foreign assignments to the Near East and Africa are also available to Division personnel who have served in the domestic programs for at least 5 years. Such assignments are with the Regional Insect Control Project, which is headquartered in Beirut, Lebanon. Assignments to positions of Country Representative are either as AID-6 or AID-5 and include quarters, cost-of-living, and educational allowances.

To supplement and support the work of the PPC Inspector, the PPC Division employs plant pest control technicians. They are

carefully selected, on the basis of experience and familiarity with local factors, to perform or supervise recurring pest control assignments. Their years of practical and specific experience in pest control techniques coupled with a knowledge of geography, industry, business, and agriculture of the area make them valuable assistants to the Inspector. Technician grades are at the GS-5, GS-7, and GS-9 level.

## Qualifications

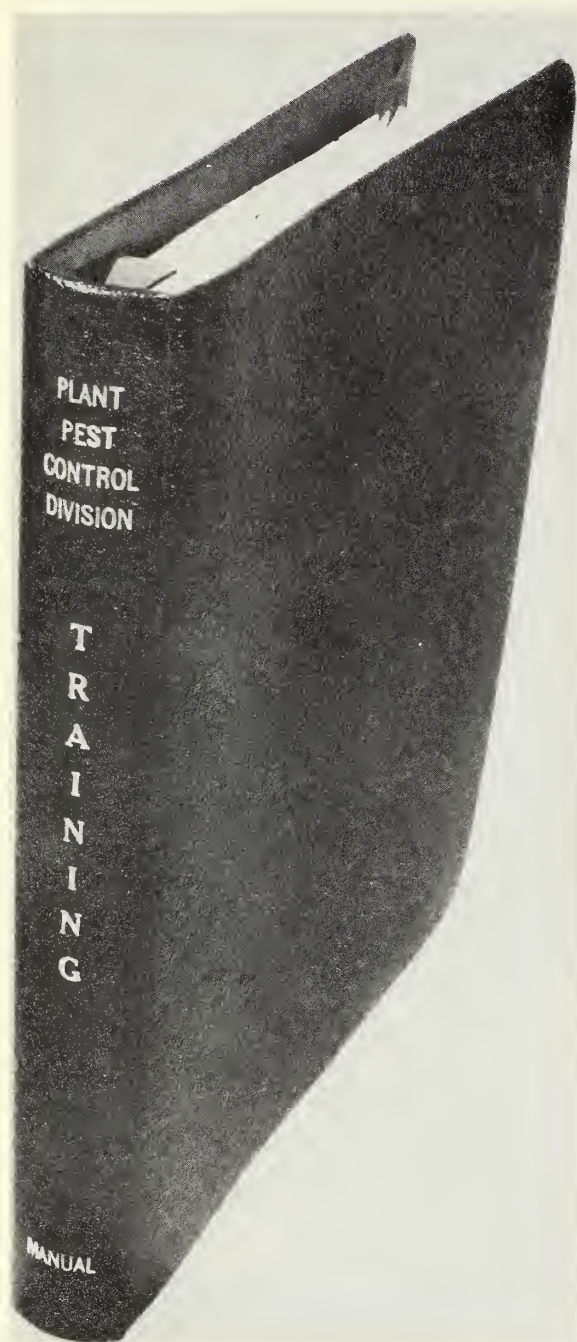
To qualify for a GS-5 rating as a Plant Pest Control Inspector candidates must have the prerequisites described under (a) or (b) below:

- (a) A full 4-year course of study in an accredited college or university leading to a bachelor's or a higher degree with major study in one of the biological sciences. This course of study must have included at least 20 semester hours of course work in any one or a combination of the following subjects: Entomology, botany, plant pathology, nematology, horticulture, mycology, invertebrate zoology, or closely related scientific subjects.
- (b) Course work totaling 30-semester hours in a biological science and related natural and physical sciences, including the 20 hours in the above specified course work; plus experience similar to the duties of a Plant Pest Control Inspector which, when combined, would total 4 years of education and experience and give the applicant a technical knowledge equivalent to that acquired through successful completion of a 4-year college course.

To qualify for a GS-7 rating the applicant must meet the following additional qualifications:

- (a) A "B" average or better and in the upper 25 percent of his class, or
- (b) One full year of graduate study, or completion of all the requirements of a masters degree in one of the specified sciences, or
- (c) One year of experience in an activity similar or related to plant pest control inspection.

## TRAINING IN THE PLANT PEST CONTROL DIVISION



N-46702

Training Manual for PPC inspector.

The Plant Pest Control Division leadership believes training can be best achieved by a supervisor-trainee team relationship which keeps the training close to day-to-day program operations. Therefore, responsibility for the actual operation of the training program falls upon the Plant Pest Control Supervisor. The first objective in the program is to prepare the employee for the basic operating skills required in the current position. The next goal is that of coaching, counselling, and stimulating the employee in preparing for broader responsibilities and for a readiness for other assignments. The complexity of the national and international scopes of the Division's activity in operating more than 20 progressively changing cooperative plant pest control programs affords much variety and challenge.

Workers in the Division with many years of experience in handling large-scale pest control actions have a dominant and valuable role in training workers new to these activities. It is the new or reassigned employee's responsibility to take advantage of training opportunities offered by this program.

Written training outlines are used as tools to accomplish basic training with the least possible delay. These aid in preventing the loss of desirable job techniques and at the same time preserve the inventory of valuable past job experiences and technical knowledges essential to PPC program operations. The guidelines are used for positions beginning with student trainee GS grades and extends upward through Plant Pest Control Inspector (GS-5, 7, and 9) positions.

The GS-9 training program takes the trainee progressively through a state-regional area of operation into a series of Division inter-regional training assignments. These assignments of 4 or more weeks' duration each are closely woven into on-the-job and managerial aspects of programs not operating within the home regions.

## COOPERATIVE PROGRAMS WITH MEXICO AND CANADA

The discovery in November 1916 of the pink bollworm of cotton in the Laguna area of Mexico caused so much concern among the cotton industry in the United States that Federal funds were made available March 4, 1917, to initiate an emergency attack on the problem.

On October 6, 1917, authority was given the Secretary of Agriculture to make surveys in Mexico and to cooperate with the Mexican Government in the extermination of local infestations of pink bollworm near the U.S. border. The Department of Agriculture, through informal agreements with Mexican officials, made surveys and carried on control work south of our border to prevent spread into this country. The population-suppressive work was continued even though the pink bollworm was found in Texas in 1917.

In 1943 formal agreements were developed between the Departments of Agriculture of Mexico and the United States. Since that time the Department has had an organization in Mexico working on pest control

problems of mutual interest--principally the pink bollworm of cotton, the blackfly and Mexican fruit fly of citrus, and khapra beetle.

The objective of the U.S. Department of Agriculture programs in Mexico is to keep pests of concern suppressed through cooperative control and to prevent spread through quarantine procedures. By such suppressive measures the danger of spread and repeated reinfestation in the U.S. would be lessened. The program has been successful enough to limit appreciable commercial damage from pink bollworm on either side of the border to limited areas in occasional years. The spread of the Mexican fruit fly has been negligible into Texas and not at all into Arizona or California. The last citrus blackfly infestation in Texas was eradicated in 1956.

Although it has not been necessary to develop jointly financed pest control work with Canada, there is active cooperation on such programs as the gypsy moth, the European chafer, and the Japanese beetle.

## FOREIGN TECHNICAL ASSISTANCE PROGRAMS

### History

In April 1951, during one of Iran's worst locust infestations on record, the U.S. Government responded to a request for assistance by dispatching an aerial unit and insecticides to that country. This was the beginning of U.S. technical assistance in plant protection in the Near East and the South Asian countries.

Originally administered by the Foreign Agricultural Service in cooperation with the Technical Cooperation Administration of the Department of State and the former Bureau of Entomology and Plant Quarantine, the Regional Locust Control Program, established in 1951, was enlarged in 1952 to pro-

vide for regional operations at the request of cooperating Nations. Full responsibility for implementing the program was vested in the Bureau of Entomology and Plant Quarantine in the fall of 1952. Overseas headquarters were established at Beirut, Lebanon. Aircraft, insecticides, and pilots under contract were made available. The planes usually operated in units of three, with an entomologist supervisor over each unit.

The Regional Locust Control Program conducted aerial spray demonstrations against the desert locust in Iran, Iraq, Pakistan, India, Jordan, and Ethiopia under individual bilateral country agreements. These agreements included host country cooperation in

providing ground support for the aircraft, transportation, lodging for U.S. personnel, labor, et cetera.

The cooperative efforts demonstrated how modern techniques of pest control can be applied successfully in programs of technical cooperation with other Governments. More attention was focused on problems of plant protection. The demands on our personnel to assist in the control of many major insect pests resulted in an important modification of the program.

The Regional Locust Control Program now operates as the Regional Insect Control Project. Under the terms of this agreement the Agricultural Research Service delegated to the Plant Pest Control Division the responsibility for the technical direction of insect control programs approved by the Foreign Operations Administration as a part of the technical cooperation with countries of the Near East, South Asia, and Africa.

Since 1954 entomologists have been stationed in 12 countries on full-time assignments. During the ensuing years the project rendered services in some 20 countries in the area.

## Objectives

Briefly, the objectives of this cooperative work are: (1) to assist the United States Missions in their efforts to aid the Governments of cooperating countries in the development of practical control programs and to supervise and direct such segments of these programs as may be agreed upon, (2) to maintain facilities and continue needed services in assisting these countries in the control of the desert locust through the demonstration of aerial spraying techniques and reconnaissance as a supplement to other control measures, (3) to train local pilots and mechanics to provide for the continuation of aerial and ground control activities and to train local technicians in field survey and in plant quarantine and control methods, (4) to give guidance and assistance in the

coordination and execution of all plant protection activities, and (5) to promote international cooperation by working with technicians and authorities of individual Nations and agencies concerned with the control of the locust and other major insect pests.

The work in each country varies with its plant protection needs, its organization, and the importance of insect pests to its agricultural economy. Our own participation within a country is based upon an agreement drawn up by representatives of the local Ministry of Agriculture, the United States Agency for International Development (AID) Mission, and the coordinator of the regional project.

## Implementation of Project

The entire cost of operating the regional project is provided from funds advanced to the Agricultural Research Service from the AID program. The Division maintains close liaison with the agency in all aspects of the work. It is responsible for budget preparation, recruitment of personnel, and all administrative matters pertaining to the operation and conduct of overseas projects.

Entomologists assigned to foreign posts are obtained largely from the Division's domestic program, while pilots are recruited from commercial sources. They are assigned only to those countries within the Near East, South Asia, and Africa where Governments have requested such services. At the foreign posts our technicians are attached to the United States AID Missions. Each country's agreement covering project activities contains provisions indicating what the host country will provide in exchange for our technical and material assistance. In the case of locust control, for example, the host country provides ground support for aerial spraying, fuel for the aircraft and assistance in its maintenance, transportation of personnel and supplies, insecticides, and technicians to supervise control operations and cooperate with the regional control personnel.



This migratory grasshopper, the desert locust, is a major pest in much of the Near East, S. Asia and Africa north of the equator.



BN-6356X

Utilizing an enormous termite mound this Ethiopian flagman guides two spraying aircraft over their targets during a locust control campaign.

The duties of project entomologists cover a wide range of responsibilities. They take an active part in aiding the U.S. Missions in planning cooperative programs. They serve as advisors to the chiefs of plant protection in the Ministries of Agriculture, aiding them in the organizational aspects of the work. Demonstrational field work with new insecticides and equipment on many major insect pests is one of the most important activities. Much of the entomologists' time is spent training nationals. They keep abreast of the insect situation and changing conditions at all times while conducting surveys and collecting specimens for identification.

## International Cooperation

Since the beginning of this project, every effort has been made to promote better international cooperation in plant protection. The strengthening of country organizations has assisted in this endeavor.

Under the Food and Agriculture Organization (FAO) of the United Nations, project personnel represent the United States delegations to FAO committee meetings dealing with all phases of their work on locusts. Special attention is also given to the insect survey and plant quarantine aspects of the Central Treaty Organization (CENTO) in Pakistan, Turkey, and Iran.



An insecticidal dust is being applied to control insects in an Afghanistan vineyard--a practical demonstration of modern control methods.



Technicians and trainees in Ethiopia are receiving guidance and acquiring new techniques from RICP insect survey specialist in an infested potato field.

## COOPERATIVE STATE AND FEDERAL PROGRAMS

### Barberry Eradication

The relationship between the common barberry, *Berberis vulgaris* L., and stem rust was recognized long before the true role of the barberry had been determined in the life cycle of the black stem rust fungus. Farmers in Europe observed this relationship between stem rust severity on grain and the location of barberry bushes more than 200 years ago. The correlation between the barberry bush and the stem rust was so consistent that the first law placing a ban on the common barberry was passed in France in 1660. This act was followed by legislation requiring the destruction of barberries in several other European countries, including Austria, Denmark, Germany, Holland, Norway, and Sweden. In England a successful voluntary program made legislation unnecessary.

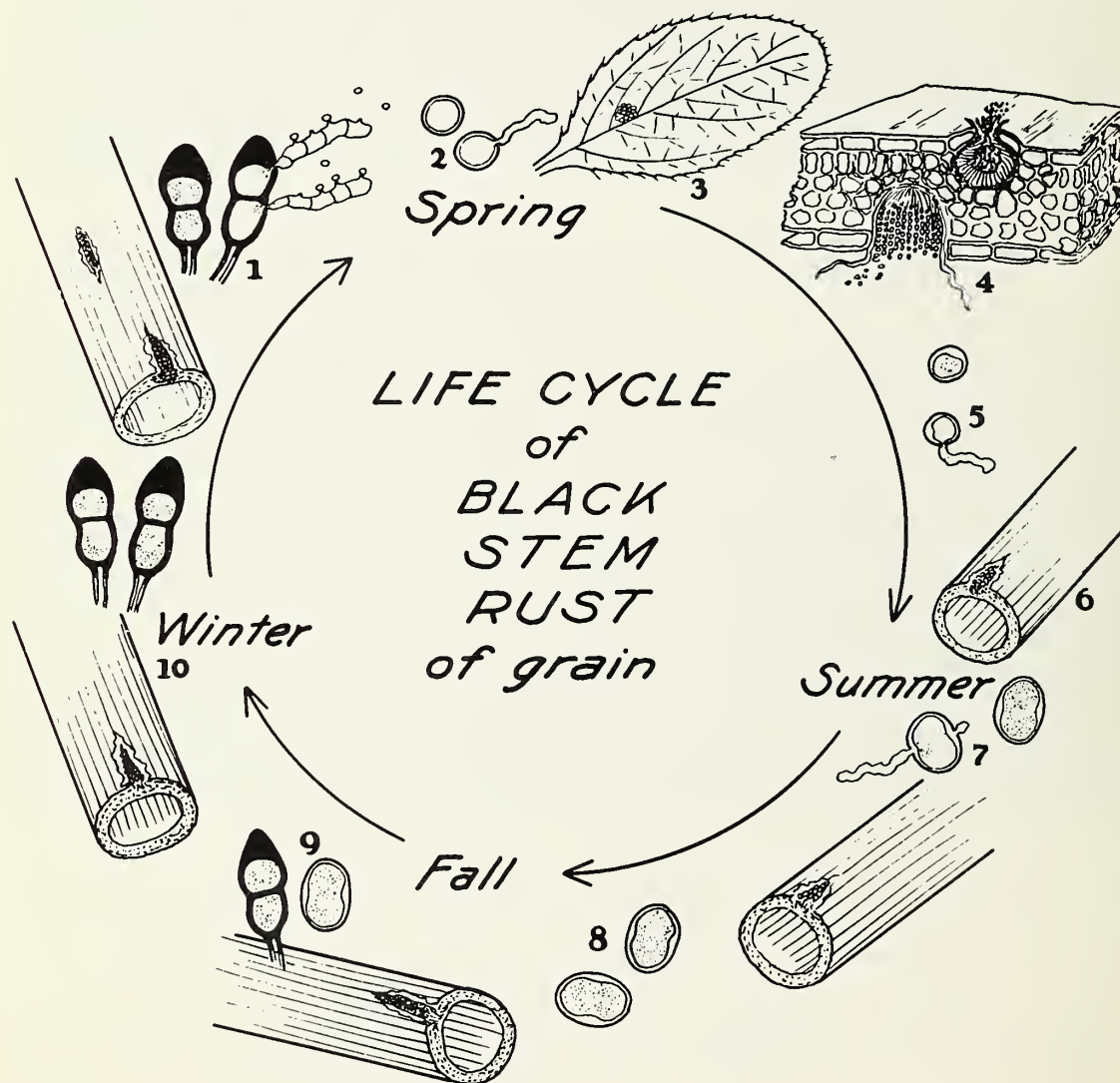
Early English settlers arriving in America had failed to recognize the relationship between the common barberry and the stem rust on grain. When they arrived in the 17th century they had with them their favorite hedge plant, seed of wheat, and other cereal crops. In a relatively short time stem rust had become a serious problem and again the relationship between the barberry bush and the occurrence of stem rust became apparent.

The voluntary destruction of the barberry failed to achieve the desired results. Following the example set by the European countries, laws requiring the eradication of these bushes were passed by the colonial assemblies of Connecticut, Massachusetts, and Rhode Island. Until the first quarter of the 20th century this was the only action taken in America to control stem rust on cereal crops by barberry eradication. Meanwhile, the common barberry had spread to

other parts of the country. Several devastating epidemics of black stem rust followed, culminating in a major epidemic in 1916. This loss of grain coupled with the increased demand for food during World War I resulted in eradication efforts by certain States in 1917. This was followed by Federal participation in 1918. At this time 13 Midwestern States joined the Federal Government in a program to eradicate the rust-susceptible barberries. There are now 19 States participating in the cooperative eradication program.

Stem rust is a disease of grain caused by a microscopic fungus that attacks wheat, oats, barley, rye, and grasses, robbing the

plants of food and moisture. In 1865 de Bary established the relationship between the black stem rust fungus, *Puccinia graminis*, and the barberry. In the Northern States the fungus overwinters in the black-spore stage on the straw of grains and grasses. This stage is not capable of reinfecting grains, but does cause infection on the leaves of the barberry in early spring. Spores from the barberry infect grains and grasses, and initiates the recurring stage in grain fields which spreads from plant to plant and from field to field. As the crops mature, the black stage again forms on the ripening straw, thus completing the life cycle.



The barberry not only bridges the gap between the overwintering spore stage and the summer stage, but also serves as host for the sexual stage of the fungus, thus providing a chance for the recombination of genes and the production of new races of stem rust. The removal of barberries on an areawide basis eliminates local stem rust sources and the only known source of new stem rust races.

The stem rust fungus overwinters in the summer stage in Mexico and the southernmost States. Inoculum from such overwintering areas is a threat to grain in important producing States of the Midwest. In occasional years widespread destructive epidemics of stem rust do develop from such sources of rust. These periodic heavy losses probably are insignificant in comparison to the countless local epidemics, which would occur annually if susceptible barberries had not been eradicated from most important grain growing areas.

Stem rust has reduced grain yields in the United States as much as 200 million bushels in a single year. Some damage from this disease occurs in some area every year. Stem rust lowers the test weight of grain and reduces the quality and yield of grain produced. Shriveled grain is heavily discounted on the market.

From the beginning the barberry eradication program has been a cooperative effort by the States and Federal Government to search for and destroy rust-susceptible species of barberry. In support of the eradication program Federal Quarantine No. 38 was promulgated May 1, 1919, to prevent the reestablishment of susceptible barberries in the eradication areas. The stem rust quarantine regulates interstate movement of plants, seeds, and fruits of *Berberis*, *Mahonia*, and *Mahoberberis*. Rust-resistant varieties of these species are permitted to be moved interstate from inspected and approved nurseries.

## Burrowing Nematode

The burrowing nematode was first observed and described by Cobb in 1890 on the roots of bananas in the Fiji Islands. Since then its presence has been reported in many

tropical and subtropical regions of the world, including Jamaica, the Hawaiian Islands, the Philippine Islands, Formosa, South India, Dutch East India, Java, Brazil, Central America, Puerto Rico, and the United States.

On citrus the pest causes a degenerative disease known as spreading decline. Although symptoms of this disease were noted in a citrus grove in Winter Haven, Fla., as early as 1928, the causal agent was not identified as the burrowing nematode until 1953. Since that time the burrowing nematode has been found in 12,000 acres of citrus in Florida, the largest number of infestations being in Lake, Orange, Polk, and Highlands Counties.

The burrowing nematode, *Radopholus similis* Cobb (Thorne), is a parasitic eelworm approximately 1/50th of an inch long. This nematode spends most of its life within the root tissues, emerging to seek new food sources only when the attacked rootlets degenerate. The destruction of the rootlets causes the host plant to decline in vigor, and reduces the yield and quality of fruit of the mature trees.

The United States Department of Agriculture joined the State of Florida in a control program in 1955. The objectives of the program were (1) to prevent healthy groves from becoming infested and (2) to eliminate spreading decline from commercial citrus groves. The essential features of the cooperative program were (1) regulations controlling the movement of nursery and ornamental stock and other materials capable of spreading the nematode, (2) strict inspection of nursery stock used for planting citrus nurseries, (3) detection and delimiting surveys, and (4) the "push-and-treat" method for eradicating infestations in groves. The push and treat procedure essentially consists of uprooting and burning trees, treatment of the soil at the rate of 60 gallons to the acre with a fumigant containing dichloropropene, and keeping the treated land free of host plants for a period of 2 years. The Plant Pest Control Division assumed the responsibility for the surveys, which are conducted to delimit the area of infestation and to detect new infestations.

By 1961 after many of the extensive infestations had been treated, difficulties were encountered in pursuing the program to completion. The drastic push and treat method was modified in September of 1961 and a buffer zone method of control was initiated. The primary feature of the new control program was the establishment in the soil of a chemical barrier capable of preventing the infestation from movement to adjacent trees. This barrier zone, approximately 25 feet in width, was treated with ethylene dibromide to kill all roots in the zone and prevent the movement of the nematode along the roots to other trees. The surface of the barrier is kept free of weeds and other host plants by treatment with herbicides. When production of fruit from the diseased trees inside the barrier becomes uneconomical, trees from the entire area will be removed and the soil treated.

The Florida Citrus Experiment Station and the Crops Research Division of the Agricultural Research Service are conducting research to find more practical means of combatting spreading decline. Several citrus root-stock varieties have been found that show resistance to the burrowing nematode. The most promising of the candidate varieties are being increased and field tested.

## Citrus Blackfly

The citrus blackfly, Aleurocanthus woglumi Ashby, referred to in Mexico as "la mosca prieta" was first described in 1915. This citrus pest is native to the East Indies, but is now known to occur throughout the West Indies, Mexico, and Central America. In 1934, the citrus blackfly was reported from Key West, Fla. Eradication measures were immediately undertaken and the infestation was eliminated. An infestation found in Sinaloa, Mexico, in 1935 spread over much of Mexico and in 1955 reached the citrus-growing area of Texas. Eradication of this infestation in Texas was completed in 1956.

In 1948 the United States Department of Agriculture and the Mexican Defensa Agrícola undertook a cooperative eradication program in northern Mexico. This program was de-

signed to eliminate infestations and to prevent the spread of the citrus blackfly to American citrus areas adjacent to the Mexican border. A chemical control zone was established approximately 100 miles wide where the Mexican Defensa Agrícola applied control measures and enforced a quarantine in the Mexican states adjoining the international border. Throughout the remainder of Mexico a vigorous biological control program has been very effective in reducing populations and limiting the number of reinfestations in the chemical control zone.

The citrus blackfly is not a true fly, but is related to the scale insects and aphids. It is a dark bluish, 4-winged insect, about 1/16th of an inch long. It spends most of its life in a stationary scalelike form with its beak imbedded continuously in the citrus leaf tissue. The female deposits eggs in a characteristic spiral on the underside of the leaves. In a lifetime she may lay more than 100 eggs. The nymphs and pupae are shaped like typical whiteflies but are quite spiny. The nymphs are dark brown and pupae are black. Three to six generations a year can be expected.

The citrus blackfly is recognized as one of the most serious pests of citrus. Uncontrolled infestations have been known to result in a total crop failure in 2 years. In heavy infestations, leaves and fruits are encrusted with sooty mold which has developed in the accumulated honeydew. This mold reduces the vigor of the trees and the quantity and quality of fruit.

The citrus blackfly program, in cooperation with the Defensa Agrícola, is conducted to prevent the introduction of this pest to the citrus-producing areas of the United States. The work is done in Mexico where infestations near the international border are eradicated with chemicals and populations throughout the remainder of the country are suppressed by the release of parasitic insects. Surveys are conducted in the citrus areas of Arizona, California, and Texas to detect infestations as soon as possible. If an infestation were found in the United States, eradication measures would be undertaken immediately.

## European Chafer

The European chafer, Amphimallon majalis (Razoumowsky), was first identified in Europe in 1789. It has been found throughout most of Europe where it feeds on forage crops, winter grains, lawns, and pastures. It was first discovered in this country in 1940 in Wayne County, N. Y., where it is believed that it was introduced with plants imported from Europe in the late 1920's or early 1930's. It has since spread to 16 counties in western New York and the Brooklyn and New York harbor area. Isolated infestations have been found in Connecticut, New Jersey, and West Virginia.

In 1942 the New York State Department of Agriculture and Markets assumed the responsibility of carrying out regulatory procedures governing the movement of materials capable of carrying the infestation to uninfested areas. The program was strengthened in 1955 by the promulgation of a Federal quarantine which became effective in September of that year. Connecticut, New York, and West Virginia have been placed under quarantine because of the European chafer. New Jersey has embarked upon a vigorous eradication program and is treating infested areas when they are found.

The adults of the European chafer resemble some of the more common June beetles. One of the characteristics distinctive of this beetle is its mating flight at dusk. The adult beetles emerge a few minutes before sundown, fly toward a silhouetted tree or other object where they swarm with a characteristic buzzing noise and are often mistaken for a swarm of bees.

The larvae of the European chafer are white with brown heads resembling the common white grub. They feed on the roots of grasses and other host plants during the summer and burrow below the frost line during the fall of the year.

The European chafer prefers the fibrous roots of hosts such as winter wheat, oats, rye, barley, and sod. It is commonly found in grassy areas but does attack legume field crops and is able to support itself on a wide variety of weeds and other plants. In heavily

infested sod areas destruction of roots may be so great that turf may be rolled from the soil surface. In some of the more heavily infested areas in New York up to 80 percent loss has been noted in permanent pastures and winter grains. When the hillside pastures are destroyed the land is exposed to erosion and all its consequent injuries.

The European chafer program is conducted to prevent further spread of the pest. This is accomplished through quarantine enforcement supported by a cooperative program to eradicate new and outlying infestations. The infestation in West Virginia has been treated and has been free of beetles for a period of several years. The entire infested area in Connecticut has been treated and an active program is underway to treat all known infestations in New Jersey.

## Golden Nematode

The first record of the golden nematode, Heterodera rostochiensis Woll., was from Germany in 1881 and for sometime it was considered a strain of H. schachtii Schm. In 1909 it was established that potatoes were hosts of this nematode, but it was not until 1923 that it was described as a new species. It attracted little attention until 1913 when it was found in Scotland. Since then it has been found in most European countries and parts of South America and Asia. The golden nematode was first found in North America in 1941 where it was damaging a field of potatoes south of Hicksville, Nassau County, Long Island, N. Y.

Since 1944 a New York State quarantine has been enforced to prevent the spread of golden nematode to uninfested areas. Extensive surveys have revealed that this nematode is present on approximately 16,000 acres on Long Island. No other potato-producing area in the United States has been found infested. At this time more than 9,000 acres of infested land have been removed from agricultural production by housing developments.

The golden nematode is one of the cyst-forming nematodes and has a characteristic

golden or light brown color. In its active stages it is a minute eelworm that attacks the roots of potato and tomato plants. It deprives the host plant of moisture and nutrients, seriously reducing the yields. Heavily infested potato fields have had the yield reduced as much as 80 percent and in some European countries this pest is serious enough that laws have been passed to prohibit forever the production of potatoes on land infested by the golden nematode.

Drastic measures have been established by the State of New York with the assistance of the U.S. Department of Agriculture to prevent the spread of the golden nematode to new fields on Long Island and to other potato-producing areas of the United States. This includes marketing regulations and restrictions on the movement of top soil and other commodities capable of carrying the golden nematode in any stage of its life cycle. In 1959 a cooperative program was undertaken by the State of New York and the Plant Pest Control Division to eradicate the golden nematode from the infested agricultural land on Long Island. Infested land is being fumigated with a total of 90 gallons per acre of the nematocide D-D in split applications of 45 gallons each about 10 days apart.

## Grasshoppers

Since Biblical times grasshoppers have been recognized as one of the major pests to compete with man for his crops and forage for his domestic animals. They are distributed throughout the world and in every State in the United States. While they do a limited amount of damage in the eastern one-third of the United States, they are a major pest in cultivated areas of the Midwest and the range areas of our Western States.

Early attempts to control grasshoppers with simple flails, mechanical devices, and noise makers to drive the grasshoppers from infested fields were mostly unsuccessful. Research programs have been underway to find efficient control methods for more than 100 years. Such things as aromatic

baits have been introduced as control methods. With the discovery of insecticides, such as Paris green, sodium arsenite, and sodium fluosilicate, some success in controlling grasshoppers became possible. The first large-scale cooperative control program was undertaken in 1934 when the U.S. Department of Agriculture joined affected States in an organized effort to control grasshopper infestations.

Since 1934 many improvements have been made in the control program. Aircraft were introduced and have become the accepted procedure for applying insecticides to large acreages of infested land. The chlorinated hydrocarbon insecticides have assured success of a control undertaking. The present control program involves the use of an insecticide requiring only one-half ounce per acre.

Most species of grasshoppers hatch during the spring months from eggs deposited in the ground the previous season. However, in Arizona hatching occurs in the spring and in the fall. The nymphs of grasshoppers resemble adults and cause damage near the place where hatching occurred. When they become adults many species are capable of migrating in flight to areas many miles from the point where they hatched.

Some species of grasshoppers will eat almost any vegetation; others feed on only a few plants. Infestations, however, seldom include a single species, and in outbreaks complete destruction of crops and range forage is a common occurrence. More than 100 species of grasshoppers feed on range vegetation, while a relatively few species prefer cultivated crops.

The U.S. Department of Agriculture conducts surveys throughout the Midwestern and Western States to evaluate infestations of grasshoppers. This information is summarized and is distributed to farmers, State Plant Pest Control officials, and other agricultural workers. In cultivated areas, the Plant Pest Control Division is responsible for and provides technical assistance to farmers indicating an interest in organizing control programs.

In the Western States where rangeland is threatened by grasshoppers, the Plant Pest

Control Division joins interested States and ranchers in a cooperative program to suppress outbreaks on rangeland. These control operations are financed jointly by the interested State, the ranchers involved, and the Federal Government. In the future it is hoped that cooperative programs can be developed to control incipient infestations while still small to prevent them from developing into outbreak proportions.

## Gypsy Moth

The gypsy moth, Porthetria dispar (L.), was brought into this country in 1869 from France by an amateur entomologist for experimental purposes. It escaped from his laboratory at Medford, Mass., and from there during the next 20 years spread to nearby towns where it destroyed many fruit and shade trees.

Following a severe outbreak in 1889, the State of Massachusetts appropriated funds for its eradication. Relying on the erroneous belief that the control work had been successful, eradication efforts ceased in 1900. Populations again built up to tremendous numbers and the State resumed its control work in 1905. Meanwhile, the pest had spread over 2,000 square miles in Massachusetts and to parts of Maine, New Hampshire, and Rhode Island. Federal funds were made available in 1906 to aid in the control effort. Despite the work that was done, the gypsy moth continued to spread. On November 5, 1912, a Federal quarantine to control the movement of articles capable of spreading infestations of the gypsy moth and the brown-tail moth was put into effect. This action, originally known as quarantine No. 4, and its subsequent revision, is still in effect under Federal Quarantine No. 45.

In 1923 a moth-free barrier zone 30 miles wide extending along the eastern border of New York from Canada to Long Island was established to prevent further spread to the West. This barrier was broken in 1938 when a hurricane carried egg clusters beyond the eradication area. No record of long-distance spread of the gypsy moth by man had occurred

until 1954 when an isolated infestation was discovered at Lansing, Mich. In 1956 plans were made to begin a long-term eradication program in the generally infested area. This program began immediately in New Jersey, Pennsylvania, and on Long Island and southeastern New York. It continued until residue problems were encountered. It has been necessary to curtail the eradication effort until alternate insecticides can be found that will not involve residue problems.

The gypsy moth larvae are brown hairy caterpillars, recognized by five pairs of blue spots followed by six pairs of red spots on their backs. They hatch from overwintering eggs in the latter part of April or early May. In late June or early July the larvae pupate and emerge as moths in July or early August. The male moth has a wing spread of 1-1/2 inches, is dark brown in color, and is a strong flier. The female moth is creamy-white with dark brown to blackish wing markings with a wing spread of about 2 inches. The female moth is unable to fly because of the weight of her body. The female deposits her eggs in clusters of 400 to 500 eggs, which are covered with brownish hairs to form a distinctive mass. They are deposited on stones, trunks of trees, fences, and other objects.

Damage is caused by larvae of the gypsy moth feeding on leaves. Repeated defoliations retard growth and may kill hardwood trees. The hemlock seldom survives a single defoliation. Weakened trees are susceptible to diseases and attacks of other insects, notably the bark borers.

It is hoped that the gypsy moth may ultimately be eradicated from the United States. That the gypsy moth can be eradicated has been demonstrated by the successful programs in New Jersey and Pennsylvania, and more recently in Michigan, where treated areas have been found free of the gypsy moth for many years. Meanwhile, efforts are directed toward the enforcement of the Federal quarantine to prevent long-distance spread supported by a cooperative program to eradicate outlying infestations. The search will continue for an acceptable insecticide

that can be used in areas where residues of chlorinated hydrocarbons are a problem.

## Hoja Blanca

Hoja blanca, or "white leaf," is a destructive disease of rice, first observed in Panama in 1952. It is caused by a virus transmitted by a planthopper, Sogatia orizicola Muir, known as the rice delphacid. Since 1952, it has been found in Guatemala, Honduras, British Honduras, El Salvador, and Costa Rica in Central America; in Columbia, Venezuela and Surinam in South America; in Mexico and United States in North America; and in Cuba and the Dominican Republic in the West Indies.

Hoja blanca was first found in the United States in Palm Beach County, Fla., in 1957 on rice on the Everglades Experiment Station. Plantings on the station and in three commercial fields found infected were plowed under and the environs treated with malathion spray to destroy the vector. Eradicative treatments against the vector were continued in 1958 and the disease has not reappeared in Florida.

Through intensive surveys throughout the rice-growing areas of other States a small infestation was located in Hancock County, Miss., in 1958. In 1959 the disease was found in 11 parishes in Louisiana and only the vector was found in three additional parishes. Multiple applications of insecticides to all areas in which the vector was found apparently eradicated the disease. Periodic surveys have been continued for the vector and the disease. The disease has not been found in any area since the 1959 crop season. Light infestations of the vector were discovered in 34 fields in 7 parishes of Louisiana in the summer and fall of 1962. Infested fields and buffer zones were treated to eradicate the vector.

Early detection and prompt eradivative action have prevented hoja blanca from becoming widespread in the rice areas. Close cooperation among the grower, industry, State and Federal groups has confined the

disease to limited areas and the program to emergency action.

## Imported Fire Ant

The imported fire ant, Solenopsis saevissima richteri Forel, is thought to have been brought into this country from South America shortly before 1920 through the port of Mobile, Ala. Although this ant had been observed around Mobile for several years, entomologists did not recognize until 1930 that it was a species distinct from the two native species of fire ants common in the Southern States. The pest appears to have been confined to southern Alabama for a number of years, but by the early 1950's it had spread to Arkansas, Florida, North Carolina, South Carolina, and Texas, with heavy infestations in Alabama, Georgia, Louisiana, and Mississippi. An infestation that had become established in Tennessee was eradicated in 1953.

For several years control of the imported fire ant was considered an individual responsibility. Even though some State money had been made available, these individual efforts failed to prevent further spread or the buildup of populations to alarming proportions.

In response to repeated appeals from the affected States for Federal assistance, the Congress in the fall of 1957 authorized the Department of Agriculture to join interested States in a cooperative program to eradicate the imported fire ant. Plans were developed jointly by the Plant Pest Control Division, the State Departments of Agriculture, and State and local imported fire ant committees to initiate the program authorized by the Congress. Special emphasis was given to the prevention of spread by eradicating outlying infestations in the states and counties outside the area of general infestation. Federal quarantine No. 81 became effective May 6, 1958. This action applied to the States of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. Its purpose was to prevent the long-distance spread of this pest by regulating commodities capable of carrying the imported

fire ant in any stage of its life cycle. This included movement of soil or articles contaminated with soil, forest products, and other infested commodities.

At the outset of the imported fire ant program, a methods improvement laboratory was established at Gulfport, Miss. The objective of this laboratory was to bridge the gap between the research entomologist and the personnel responsible for the eradication program. Starting with available data provided by research agencies, the laboratory began its work to develop new control treatments--the adaptation of aircraft and ground machinery to the program, the improvement of known insecticide formulations, and screening a wide variety of materials in an effort to find new pesticides which could be used in the eradication program.

Mounds of the imported fire ant vary in size because of age and type of soil but are commonly about 1 foot high and 2 feet across. Each such mound may contain some 25,000 ants. Mounds may be built in almost any type of environment but open sunny sites are preferred. They are more numerous in pastures, meadows, parks, lawns, and uncultivated areas.

In the fire ant program infestations are treated with low dosages of insecticides or with attractant baits. Emphasis is placed on the eradication of outlying infestations and the application of eradication treatments on the periphery to progressively reduce the perimeter of the generally infested area. The Federal and parallel state quarantines are vigorously enforced to prevent local and interstate spread from the infested areas.

Based on ecological information from South America, this pest could become established farther north and west of its present range. Efforts are being continued to find more effective materials with which to deal with the problem. Much progress has been made through methods improvement which has demonstrated that improved formulations of heptachlor have resulted in the reduction of effective pesticides from 2 pounds of actual material per acre to 1/2 pound. In 1962 tests were completed with a new bait, which was adopted as the standard treatment

under most conditions. This fire ant bait consists of corncob grits impregnated with soybean oil containing a new insecticide known as mirex. With this formulation, only 1/7 of an ounce of the toxicant is applied to the acre in a single treatment. In some areas a second application will be necessary to effect eradication.

The worker ant is the most numerous form and is 1/8 to 1/4 inch long, is blackish-red to reddish-brown, wingless, and usually sterile. The other two adult forms are the winged female or queens which lay eggs and the winged males. An ant colony begins when the queen after mating digs an underground chamber and starts laying her eggs. She lays her first cluster, from 10 to 25 eggs, which hatches in 8 to 12 days. By the time they hatch an additional batch of 75 to 125 eggs has been laid. Egg laying ceases until the first brood of workers has been reared to care for the colony and the young. As the ant colony increases the size of the mound continues to grow. As the infestation increases, as many as 50 to 75 mounds or more per acre frequently occur.

The imported fire ant is a major pest in heavily infested urban and rural areas. On the farms its mounds damage machinery used in harvesting hay, forage, and seed crops and the ant interferes with hand labor in the fields and orchards. It is a major nuisance around homes and farmplots and has damaged some crops either by attacking the young seedlings or building its mounds in such crops as baled hay left in the field for a short period of time. In urban areas it prevents the full use of yards and recreation areas. The mounds are unsightly in cemeteries, lawns, parks, and roadways, and they increase maintenance costs. In addition the sting is painful to everyone, and is particularly dangerous to the few who are allergic to fire ant venom.

## Japanese Beetle

The Japanese beetle, *Popillia japonica* Newm., was first reported in the United States at Riverton, N. J., in 1916. It was

thought to have been brought into this country with plants imported from Japan prior to 1916. When first discovered little was known about its habitats in Japan and there was nothing to indicate whether it would become destructive in the United States. It soon became apparent, however, that the Japanese beetle had found ideal conditions for rapid multiplication and that it was capable of causing great loss to many economic crops and plants.

In 1918, the Department and New Jersey undertook a program to exterminate the Japanese beetle, but the infestation had become so well established that it could not be eradicated by the control measures then known and with the funds available. Measures were then undertaken to develop a program to prevent the rapid spread of this pest to other parts of the country.

On June 1, 1919, the Federal Japanese beetle quarantine became effective. The objectives of this regulatory program are to retard the spread of the pest to new areas.

The Federal Japanese beetle quarantine is vigorously enforced to prevent long-distance spread. Regulations apply to soil, balled and burlap nursery stock, grass sod, plant crowns or roots and bulbs which might carry Japanese beetle larvae. Insecticide soil treatments, soaks, dips, and fumigations are used to destroy the grubs. Nurseries apply approved dosages of residual insecticides to make their stock eligible for certification.

Aircraft have been determined to be a means of spread for hitchhiking Japanese beetle. Where beetles have built up to large numbers at airports, the departing aircraft are treated with a micronized DDT. In 1960 a long-range program was begun to treat the turf areas at airports to reduce populations and thereby minimize this spread hazard. Motor vehicles and railroad reefer cars have also contributed to the spread of the Japanese beetle. Progress has been made toward developing a program of soil treatment for transportation centers, marshalling yards, and other such areas to reduce their hazard. For several years the regulatory program has been supported

by a vigorous program to eradicate outlying infestations. The infestation in California, involving some 1,700 acres, has been treated in its entirety with foliage sprays and soil insecticides.

Intensified surveys are conducted at the periphery of the generally infested area and transportation centers throughout the remainder of the United States.

Since the Japanese beetle was discovered in 1916, it has spread northward to Canada, westward to Iowa, and south into Georgia. On June 7, 1961, an isolated infestation was found at Sacramento, Calif.

The adult Japanese beetle is a metallic brown and green insect about one-half inch long, marked with 12 patches of white hairs along the sides and back of the body under the edges of the wings. Adults emerge from the soil in mid-May in southeastern North Carolina, and progressively later in the Northern States, the last emergence occurring in July in New England. The adult beetle lives approximately 30 days, during which time it deposits eggs in the soil. The larvae resemble the common white grub. When full grown they are about 1 inch long.

The Japanese beetle feeds on some 275 kinds of plants among which are grapes, peaches, apples, soybeans, and a large group of ornamentals. The beetles reduce the leaves to lacelike skeletons; fruit is rendered unfit for human consumption as a result of the ravenous feeding on the adult beetles. The grubs do extensive damage to turf in pastures, lawns, and golf courses.

## Khapra Beetle

The khapra beetle, *Trogoderma granarium* Everts, was first described from India in 1898. This insect, considered one of the most serious pest of stored grain to the world, is now reported from all principal grain-growing areas, except Australia, Canada, northern and central Europe, and South America. The first known occurrence of this insect in the United States involved a warehouse at Alpaugh, Tulare County, Calif., which was discovered infested in November

1953. There is evidence, however, that the beetle may have been present in a warehouse at Fresno, Calif., as early as 1946. In 1954 the beetle was found in Arizona, New Mexico, and Baja California, Mexico. It was later found in Texas in 1959.

On February 21, 1955, Federal quarantine No. 76 became effective to regulate the movement from infested premises of commodities that are capable of carrying the khapra beetle to new locations. Even though the fumigation of infested properties is current with the discovery of the new infestations, the quarantine has remained in effect since its promulgation in the event some delay is encountered before the infested property can be fumigated.

The adult khapra beetle, a dermestid, is a brownish black oval-shaped beetle, the female being about 1/8 inch long and the male smaller. The newly hatched larva is about 1/25th of an inch long with a yellowish-white body and a brown or yellowish-brown head. The mature larva is about 1/4th of an inch long, is a hairy yellowish worm with reddish-brown stripes across its back giving a ringed appearance. The underside of the larva is a uniform cream color. The khapra beetle larvae are found mostly in the top 2 feet of grain in bulk storage, but they have been known to penetrate as deep as 9 feet. The larvae have a habit of crawling into any kind of crevices to molt or pupate, making surveys a special problem. Favorite places of refuge are in the seams and ears of sacks and between the timbers of bins. It has even been known to subsist without food for long periods of time in such places as the airholes of concrete walls.

The life cycle of the khapra beetle is completed in 26 to 220 days depending upon the temperature. Temperatures of 90° to 95° F. are optimum, and yet the larvae have been known to withstand a temperature of zero for a few hours.

The khapra beetle larvae can subsist on a wide variety of stored products but seem to prefer grain and grain products. Young larvae of the first three instars are unable to attack sound unbroken kernels of grain and must subsist on dockage and broken

kernels until they reach the fourth instar and are able to attack large kernels. The larvae work near the surface of the grain in bulk storage, destroying from 5 to 30 percent of the material in storage. Damage up to 75 percent has been reported. It has been found in oats, wheat, corn, beans, nuts, alfalfa seed, castor beans, and a wide range of other material. Bulk grain in storage presents the most favorable conditions for beetle multiplication and subsequent damage.

The Plant Pest Control Division, in cooperation with the States and the Republic of Mexico, has undertaken a program to eradicate the khapra beetle from the Western Hemisphere. When an infested property is found it is immediately placed under quarantine regulations and scheduled for fumigation. In the fumigation process, infested buildings are covered with gas-tight tarpaulins and methyl bromide is introduced at the rate of 5 pounds per 1,000 cubic feet. Additional methyl bromide is added, if necessary, to maintain the gas concentration of 2 pounds or over per 1,000 cubic feet for 24 of the 48-hour fumigation period. The environs of the fumigated structure are surface treated with malathion at the rate of 5 pounds active malathion per 100 gallons of diesel oil.

Intensive surveys will be conducted until it is certain the khapra beetle has been eradicated. Priorities have been established to survey the establishments most likely to become infested within the infested states and near the ports of entry. This is also an insect that will be given particular attention in the Division's detection program.

## Mediterranean Fruit Fly

The Mediterranean fruit fly (Medfly) program consists of three distinct phases, the intensity of each depending upon the presence or absence of infestation. When an infestation is present, delimiting surveys are made, restrictive quarantines are invoked, and eradication treatments applied. The eradicator is the insecticide malathion in combination with a protein hydrolysate, an attractant.

In the absence of infestation detection surveys are maintained. These surveys involve the use of traps baited with a food lure distributed throughout suspect areas such as ports of entry and commercial fruit areas to detect new introductions before infestation becomes widespread. The trapping program is concentrated in Florida but some are distributed along the Gulf Coast area and in Arizona and California.

The Mediterranean fruit fly, Ceratitis capitata (Wied.), a native of the Mediterranean area, occurs in many countries of Europe, Asia, Africa, and South America. It has recently become established in Central America, in Costa Rica, and Nicaragua. It is one of the most destructive fruit and vegetable pests, attacking more than 200 crops which include most commercial fruits and fleshy vegetables. Heavy infestations can cause complete loss in a crop, and losses of 25 to 50 percent are not uncommon.

The Medfly has invaded Florida three times--in 1929, 1956, and 1962. The first infestation, involving 20 counties, was eradicated in 1930. The 1956 infestation involved some 800,000 acres in 28 counties before it was eradicated in late 1957. The 1962 infestation found through the trapping program involved parts of Dade, Broward, and Palm Beach Counties. This infestation is under eradication treatment.

The adult fly is slightly smaller than a house fly. Its body is yellow tinged with brown. In Florida it is capable of producing about 10 generations a year. The female pierces the skin of a host fruit and deposits up to 10 eggs in the puncture. The eggs hatch into larvae in 2 or 3 days. Upon maturity the larvae leave the fruit and pupate in the soil from which the adult fly emerges in 8 to 14 days. Survey, quarantine, and eradication phases of the program are designed to locate infestations as early as possible, prevent their spread, and eradicate them as soon as possible. The development of highly effective attractants, which can be incorporated into insecticide bait sprays, makes possible the low cost treatment of large areas, including urban sites.

Since the infestation in Costa Rica and Nicaragua poses a threat to the fruit-growing areas of Texas and the Southwest, a detection survey was inaugurated in 1961, in cooperation with the Republic of Mexico along the Mexico-Guatemala border as a protective measure.

## Mexican Fruit Fly

The Mexican fruit fly, Anastrepha ludens (Loew), native to northeastern Mexico, has spread in recent years throughout much of the citrus area of Mexico. It is now found in small numbers in northwestern Mexico near the California border. Each fall and winter large numbers of flies migrate to southern Texas and infest grapefruit and oranges in groves of the Rio Grande Valley. The first infestation in the United States as a result of those flights was discovered in a grapefruit planting near Mission, Tex., in April 1927.

Even though unfavorable weather and the lack of host plants during the summer months prevent the Mexican fruit fly from becoming permanently established in Texas, it still represents a threat to the citrus areas in the United States. To prevent the movement of infested fruit from the Rio Grande Valley, a Federal quarantine was promulgated and became effective on August 15, 1927. During the period flights are present all fruit moving from infested counties in Texas to other citrus-producing areas of the United States is either fumigated or treated in such a way that the Mexican fruit fly larvae are destroyed.

The adult Mexican fruit flies are beautifully colored and considerably larger than house flies. They have yellow-brown bodies and their wings are banded with yellow and brown. The larvae are white, legless, and move by expanding and contracting body segments. When the larvae mature they leave infested fruit, which has usually fallen to the ground, and burrow into the soil where they pupate. The Mexican fruit fly produces 4 to 6 generations a year. The shortest period from egg to adult is about 36 days.

Citrus fruit and other host plants are damaged by the larvae of the Mexican fruit fly. The female fly deposits her eggs beneath the rind of the citrus fruit with a sharp needlelike ovipositor. From 1 to 10 eggs are laid in the pulp of the fruit. The larvae hatching from these eggs in the fruit make it unfit for human consumption.

The Plant Pest Control Division, through enforcement of the Mexican fruit fly quarantine, prevents the spread of the pest within the United States. In cooperation with Mexico the movement of infested fruit is controlled in an effort to prevent new infestations from becoming established in northwestern Mexico. Infested properties in northwestern Mexico are treated promptly when discovered. The Division also cooperates with the State of California in a preventive program to preclude the establishment of the Mexican fruit fly in southern California. The Division furnishes insecticides that are applied by the State whenever the fruit fly is captured on or near the California border.

## Mormon Crickets

Historians in their accounts of past events of importance to Utah invariably refer to the miracle of the sea gulls. This true story marks one of the earliest records of a serious outbreak of the Mormon cricket, Anabrus simplex Haldeman, and established it as a serious pest of range and crop land in our Western States. Outbreaks of some magnitude have occurred periodically since 1848 when the early settlers in the Salt Lake Valley were saved by the sea gulls arriving on the scene to destroy the hordes of crickets attacking their crops. The largest outbreak on record occurred in 1938 when more than 19 million acres in 11 States were overrun by bands of Mormon crickets.

Over the years many weird control methods have been devised to destroy Mormon cricket infestations, one of which includes the recommendation that sheep be herded across migrating bands. Various kinds of flame throwers and torches have been used; devices, some of which were turned by water

wheels were suggested to crush crickets; and oil and water barriers were in some cases effective. Later on, tin fences were used to divert the marching bands of crickets to holding areas where they were destroyed. It was not until 1938 that the first effective control program had been developed. At this time baits were made available through research for use against the Mormon crickets. Over the years, they have been improved as new materials and information became available. Our present bait is rolled wheat impregnated with an oil solution of aldrin. This formulation is nearly specific to Mormon cricket and is a highly effective control, stopping the march of migrating bands.

By applying bait materials to Mormon cricket bands wherever and whenever they were found, the tremendous infestation of 1938 was reduced to 116,000 acres by 1949. This approach demonstrated the feasibility of suppressing and maintaining control of Mormon cricket infestations and became the forerunner of our present program.

The Mormon cricket is a large, wingless grasshopper. Its range extends from the Missouri River westward to California and from the Canadian border to northern Arizona. It maintains itself in permanent breeding areas in the mountain ranges of the West. When the populations increase to high concentrations the crickets begin banding and move out to infest adjacent range and farmlands. Two or three years are usually required for an outbreak to develop. Mormon crickets attack approximately 250 species of range plants and all cultivated crops they come in contact with. They are particularly fond of grass seed and during outbreaks seriously interrupt the natural reseeding of our western range.

In the permanent breeding areas Mormon crickets are likely to be found as solitary crickets. In this phase Mormon crickets are greenish purple in color which differs from the migratory phase. As migratory crickets they are reddish brown and move in distinct bands. The size of a band ranges from a few yards to several miles across.

Infestations of Mormon crickets are at the lowest level ever recorded. In cooperation

with the affected States the present program is designed to hold Mormon crickets at this level. All known breeding areas are kept under constant observation. As soon as migratory tendencies appear among the crickets on the breeding areas, a control program is initiated. All control work is conducted insofar as possible on the breeding grounds.

## Peach Mosaic

A disease of peaches, subsequently determined to be peach mosaic, was brought to the attention of the U.S. Department of Agriculture in 1931 from a grove near Bangs and Clyde, Tex. A similar disease had also attracted the attention of peach growers and pest control officials in Colorado that same year. In 1933 this new disease was discovered in California. It is now known to occur in Arizona, Arkansas, California, Colorado, New Mexico, Oklahoma, Utah, and Texas.

Peach mosaic is caused by a virus transmitted from diseased to healthy trees by a microscopic eriophyid mite, Eriophyes insidiosus Keifer and Wilson. The mosaic virus may also be transmitted artificially by budding or grafting from any part of the affected trees. Peach mosaic is a debilitating disease and does not kill the tree. The commercial value of a severely infected planting may be destroyed in 3 to 6 years.

Mosaic infected trees present symptoms that vary with the season, the variety, and the part of the tree affected. The most important symptoms may be classified in five general groups: (1) Color breaking in the blossom petals of the varieties that have large pink blossoms, (2) retardation of foliage development, (3) mottling and deformity of leaves, (4) deformity of fruit, and (5) abnormal twig growth.

The cooperative Federal-State peach mosaic control program was begun in 1935 to prevent further spread of the disease. Commercial orchards are inspected to locate infected trees that are removed by the owners. State quarantines are enforced to insure disease-free budwood and nursery stock.

Detection surveys are conducted throughout the commercial peach areas to detect new infestations as soon as possible.

The only control of peach mosaic disease involves the destruction of diseased trees following inspection. This program undertaken on an organized area-wide basis has successfully reduced the incidence of disease throughout the commercial peach-producing areas in those States where the disease has been found.

## Phony Peach Disease

About 1885 peach growers at Marshallville, Ga., became concerned about a disease affecting their peaches. This was the first observation of phony peach disease in the United States. Since that time this disease has spread to 12 States east of and including Texas. It is considered a serious threat to the commercial peach production in Georgia, Oklahoma, South Carolina, southeastern Arkansas and Missouri, eastern Texas, and northern Louisiana. In 1948 it was reported that four species of leafhoppers were the vectors of the phony peach disease virus. Two of these, Homalodisca coagulata (Say) and Oncometopia undata (F.), appear to be more important in transmitting the disease. In 1929, a cooperative program was put into operation to control the disease. It was supported by a Federal quarantine which remained in effect until 1934. Since 1934 regulations have been maintained under uniform state quarantines.

Infected trees are dwarfed, have a deep green color, and present a rather compact appearance in comparison with healthy trees. The internodes are shortened and foliage is flattened. Viewed from a distance the phony tree has more or less an even outline; a normal tree with long terminal growth presents an irregular outline. The trees infected with the phony peach virus bloom earlier, come into leaf earlier than normal trees, and retain their foliage longer in the fall. Fruit on infected trees is much smaller in size and quantity. Phony peach disease like peach mosaic does not kill the tree, but

weakens it, seriously reducing the commercial value of the affected trees. Almonds, nectarine, apricot, and plum are also affected by this virus.

Uniform state quarantines are enforced to prevent further spread of the phony peach disease through the movement of nursery stock. Groves are inspected annually to locate infected trees which are removed by the growers. This reduces the incidence of the disease and aids in the control of local spread. Detection surveys are also conducted to locate any new infection. With the discovery that the wild plum acts as a symptomless host of the virus, thickets in the vicinity of orchards are removed. The success of this program like many others depends upon community action to maintain profitable production of peaches.

## Pink Bollworm

The first published report of the pink bollworm appeared in 1842 and involved records of specimens collected from cotton plantations in India. Since that time it has been reported from east Africa, Egypt, and in 1909 was found in the Hawaiian Islands. Its damage in the Hawaiian Islands was so severe that the production of cotton was abandoned. In 1916 the pink bollworm was identified from the Laguna region of Mexico. This infestation is presumed to have been introduced from Egypt on shipments of cotton seed to this region in 1911. Yield reductions of 15 to 25 percent were reported. It reached the United States in infested cottonseed, moved from the Laguna region to oil mills in Texas, and became established in nearby fields, being first reported at Hearne, Tex., in 1917. It has since spread to Arizona, Arkansas, Louisiana, and New Mexico, and throughout Oklahoma and Texas.

Following the discovery of the pink bollworm in the United States a vigorous program was undertaken to eradicate it. Non-cotton zones were established in the vicinities where infestations had been found. In several instances eradication was achieved and the areas remained free of pink bollworm for

some time. The pest continued to appear in new areas and on August 1, 1920, a Federal pink bollworm quarantine was established to retard the spread of the pest. This quarantine with subsequent revisions has remained in effect since that time.

The adult pink bollworm is a small brown nocturnal moth about 4/5 inch from tip to tip of extended wings. The female begins laying eggs a night or two after emergence and will lay about 200 eggs. Most of the eggs are laid on the base of maturing green bolls except early in the season when eggs are deposited on squares. The eggs hatch within 4 or 5 days. The larvae then bore into the boll or square. The mature larvae are about 1/2 inch long with a pinkish coloring. Summer brood larvae will complete their growth in 8 to 12 days. After maturing, they cut out of the boll, drop to the ground, and pupate or hibernate, as environmental conditions dictate, in surface trash or in cracks in the soil. The pupal stage lasts 8 to 10 days in the summer, but is usually longer in the cooler weather of spring and fall.

The pink bollworm, Pectinophora gossypiella (Saund.), is recognized as one of the world's most destructive pests of cotton. The newly hatched larvae eat their way into the bolls where they feed 10 to 14 days on the seed. The entire contents of the seed or parts of several seeds may be eaten by one larva. The lint produced on hollowed out seed is weakened and shorter than from a normal seed. Moving from seed to seed the lint is cut. In addition to the oil and lint loss the grade of cotton is often substantially lowered because of stains caused by larval feeding.

Even though the area infested by the pink bollworm is relatively large, only one-third of the cotton produced in the United States is grown in the generally infested area. The cooperative Federal-State pink bollworm program is conducted to prevent further spread of the pest and to suppress populations within the generally infested area through cultural means. This is accomplished through vigorous enforcement of the Federal and paralleling state pink bollworm quarantines. The States have established cultural control

programs involving stalk destruction and sanitary measures to reduce pink bollworm populations. In support of the regulatory program to prevent spread, outlying infestations to the west and east of the generally infested area are included in an eradication effort. The most recent attempt to eradicate an outlying infestation is that of the program in central Arizona which now appears to be in the final stages. Vigorous cultural control programs supported by a limited amount of chemical treatment in Arkansas and Louisiana appear to be successful.

Detection surveys are conducted throughout the cotton areas not known to be infested to discover at the earliest possible moment any extension of the generally infested area and to locate new infestations. Evaluation surveys are also conducted within the generally infested area in support of the regulatory program.

Discovery of heavy infestations of pink bollworm in wild cotton and ornamental or dooryard cotton in southern Florida led to a program of eradicating all wild or dooryard cotton plants there. This program began in 1932 and continued through June 1947 when it was discontinued for lack of funds. Wild cotton plants and pink bollworm infestations increased rapidly. On July 1, 1949, funds again were made available to continue the wild cotton eradication work. The removal of host plants has reduced this pink bollworm infestation to a low level. Infestations in this area, if left untended, would provide a source of infestation to the cultivated cotton in northern Florida and Georgia.

## Soybean Cyst Nematode

The soybean cyst nematode, *Heterodera glycines* Ichinohe, a serious pest of soybeans in Asia, was first found in the United States in New Hanover County, N. C., in 1954. It had been called to the attention of agricultural authorities because of poor yields and difficulty in growing soybeans. This nematode has been known for many years in Japan, Korea, and Manchuria, and causes a disease known as "yellow dwarf."

Soon after the discovery of the pest the States requested assistance in making surveys to determine the extent of the infestation. In March 1955 the Plant Pest Control Division issued an alert to the States in which soybeans are produced commercially, urging them to be on the lookout for unexplained soybean losses. In November 1956 a new area was found infested in Lake County, Tenn. The following month an infestation was discovered in Missouri. Infestations were discovered in Arkansas, Kentucky, and Mississippi in 1957. In 1958 the soybean cyst nematode was found infesting fields in Virginia, and in 1959 was found in Illinois.

In March 1956, North Carolina imposed a quarantine on the movement of soil and plant parts, machines, and other articles or materials that might spread the infestation. With the discovery of new infestations, the Federal quarantine was promulgated and became effective July 26, 1957. Portions of Arkansas, Illinois, Kentucky, Mississippi, Missouri, North Carolina, Tennessee, and Virginia are now under regulation.

The soybean cyst nematode is a root parasite, about 1/50th of an inch in length. The nematode attaches itself to the young roots and feeds upon the cell contents. The mature female lays part of her eggs externally, but keeps most of them within her body which develops into a brown lemon-shaped protective cyst. The eggs laid externally soon hatch, produce larvae, and start the life cycle again. Several generations may be produced in a single season. The eggs within the cyst hatch and attack plants the following season or they may remain dormant in the absence of host plants for several years.

Damage is caused by the nematode destroying the roots of the soybean plant. It may cause yellowing and stunting of the plants--a condition known as "yellow dwarf" in Japan. Typical foliage symptoms of the disease may not appear when the soybeans are grown in heavy fertile soil with ample moisture. In areas of light, sandy soil the disease often drastically reduces yields and in severely infested fields may destroy the entire crop.

The soybean cyst nematode program is a holding operation. No satisfactory chemical treatment is currently available for eradicating the soybean cyst nematode. Intensive surveys are conducted at the periphery of the generally infested area and throughout the soybean growing area to determine the extent of the current infestation and discover any new ones that may be present. Meanwhile, Federal and parallel State regulations or quarantines are enforced to prevent further spread of this pest.

Several lines of research are underway to find a practical method of controlling or eradicating the soybean cyst nematode. These include crop rotation studies, screening of soil fumigants, and testing soybean varieties for resistance. The most promising development has been the discovery of a soybean variety that shows resistance to damage by the nematode. Additional work is needed, however, before it is commercially acceptable. In the meantime, farmers are encouraged to rotate their crops in an effort to reduce nematode populations. This will lessen to some degree the spread hazard and help prevent new infestations from becoming established.

## Sweetpotato Weevil

One of the most destructive insect pests attacking sweetpotatoes was first reported in the United States in Louisiana in 1875. The sweetpotato weevil, Cylas formicarius elegantulus (Sum.), is a native of the orient and is presently distributed throughout the world in the tropical and semi-tropical regions. It now occurs in the sweetpotato-producing areas of Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas.

A Federal quarantine against the importation of sweetpotatoes into the United States because of the sweetpotato weevil has been enforced since 1918. All other quarantines pertaining to this pest have been promulgated by and under the authority of the respective States concerned. Since 1937, when the cooperative sweetpotato weevil program began, Federal assistance has been provided the

States in the enforcement of quarantines and in carrying out other control and eradication measures.

The adult sweetpotato weevil is about 1/4 of an inch long and resembles a large ant. The head, snout, and wing covers are dark metallic blue. The prothorax and legs are reddish orange. The adult has well-developed wings and is capable of limited flight. It lays small eggs that are yellowish white. The larvae are white, legless grubs, about 3/8 of an inch long, when full grown. The pupa is white and somewhat smaller. The larvae or grubs cause the principal damage by burrowing through the potato, leaving it with a bitter taste that makes it unfit for human and sometimes animal consumption. The adult weevils damage the sweetpotato plants by feeding on leaves, vines, and roots, and by pitting the potato with feeding and egg deposition cavities. The larvae feed in both the vines and the potatoes. Growers frequently have losses ranging from 20 to 50 percent of the crop in the field and some additional damage in storage. The weevil is so abundant in some sections of the Southern States that sweetpotatoes cannot be grown profitably.

Sweetpotato weevils also develop in certain morning-glories and related plants. The insect host relationship is not entirely clear, but apparently the wild seaside and marsh morning-glories are important as host plants. Certain of the cultivated morning-glories also may have to be considered in eradication projects that involve urban districts.

A successful sweetpotato weevil program depends upon strict adherence to recommended procedures and constant care on the part of the owner to prevent reinfestation. The cooperative sweetpotato control program has the following objectives (1) eradicate the weevil in areas where feasible, (2) suppress populations, and (3) prevent its spread to uninfested areas. This requires intensive surveys to locate outlying infestations, establishing nonsweetpotato growing areas, conducting cooperative control programs in areas of heavy commercial production, and treating sweetpotatoes shipped from infested areas and those going into storage.

## White-fringed Beetle

The name white-fringed beetle is used in the United States to refer to a group of species and races of beetles belonging to the genus, *Graphognathus*. They are believed to have been brought into this country from South America, where they occur in Argentina, Brazil, Chile, and Uruguay. It was first found in Okaloosa County, Fla., in 1936. Since that time the white-fringed beetle was spread to 11 Southern States and New Jersey, including isolated infestations reported from Kentucky and Virginia in late 1960.

In 1937 the white-fringed beetle was causing serious damage to cotton, corn, peanuts, and velvetbeans in Florida. Entomologists and officials from several States who visited the area concluded that the white-fringed beetle was a serious threat to a wide range of cultivated crops elsewhere in the United States. State and Federal officials agreed that a cooperative Federal-State program to control the spread of the white-fringed beetle should start immediately along with control efforts. A Federal quarantine to prevent the spread of the white-fringed beetle became effective January 15, 1939.

The adult white-fringed beetle is a little less than a half inch long and brownish gray in color. It gets its name from the light band along the margins of the wing covers. Because the wing covers are fused together the beetle cannot fly. All adults are females and reproduce parthenogenically. Under favorable conditions the white-fringed beetle lays 600 to 700 eggs that are cemented in small masses to plant stems, sticks, debris, or soil particles. The eggs hatch in about 15 days and the larvae enter the soil where they feed on plant roots. Most larvae are found in the top 9 inches of soil, however, extensive feeding usually occurs nearer the surface. The larvae are white, legless and about 1/2 inch long when fully grown.

White-fringed beetles seriously damage many field crops, garden, ornamental, and wild plants. Most of the damage is caused by the larvae feeding on plant roots. The adults do some damage by feeding on foliage. The white-fringed beetle feeds on at least 385

species of plants of which some of the common host plants are peanuts, velvetbeans, soybeans, lespedeza, clover, alfalfa, cotton, corn, strawberries, white potatoes, chrysanthemum, dahlia, and a series of weeds. Damage ranging as high as 70 percent has occurred in the areas where the pest was originally found. Relatively general use of effective chemical soil treatments in heavy population areas is currently holding economic damage to low levels.

The white-fringed beetle control program is concerned primarily with preventing further spread to uninfested areas of the United States. This is accomplished through vigorous enforcement of Federal and parallel State quarantines which regulate the movement of commodities capable of carrying the white-fringed beetle. The regulatory program is supported by vigorous action to eradicate outlying infestations and a program to suppress heavy populations within the generally infested area. An infestation which was discovered in Cumberland County, N. J., November 18, 1954, has been eradicated. Infestations in Kentucky and Virginia have been treated. Work is currently underway to treat all infestations in Arkansas and Tennessee.

## Witchweed

Late in the summer of 1956, witchweed, *Striga asiatica* (L.), was found seriously damaging corn in 8 adjoining counties of North Carolina and South Carolina. This was the first record in the Western Hemisphere of this serious parasitic plant that attacks corn, sorghum, sugarcane, and more than 140 species of plants in the grass and sedge family. Witchweed has been known to exist in Asia, Africa, and Australia since 1790. In 1900 it was recognized as a serious parasitic weed in South Africa.

Recognizing that this new pest represented a serious potential threat to the Corn Belt of the Midwest and the sugarcane areas of the South, the U.S. Department of Agriculture took immediate steps to prevent its spread and joined with the affected States to locate

and eradicate established infestations. A Federal quarantine was invoked on September 6, 1957, that applied to all infested areas to regulate the movement of articles capable of carrying witchweed seed. The movement of soil, underground parts of plants, hay, and other fodder, seedcotton, tobacco, peanuts, earcorn, soybeans, farm machinery, and construction equipment, and all types of containers used to harvest and transport farm equipment is regulated under the Federal quarantine.

Intensive surveys were undertaken immediately to delimit the infested areas and large-scale field tests of the "catch crop" and herbicide control methods were initiated. Because little was known about the control of witchweed a Methods Improvement laboratory was established at Whiteville, N. C., in cooperation with the Crops Research Division to search for the most effective means of controlling the witchweed. At this laboratory new chemicals are screened for effectiveness against the witchweed, and a search is underway to isolate the material which stimulates germination of the witchweed seed.

The witchweed plant is identified by its small flowers that are usually brick-red or scarlet. Occasionally yellow or almost white blossoms appear. Leaves are slightly hairy and the plants rarely grow more than 8 to 10 inches high. Occasionally plants 18 inches high have been found. Following germination of the witchweed seed the plant develops underground for 6 weeks to 2 months. It is during this period that the witchweed parasitizes the roots of the host

plant and the principal damage occurs. Following this period of underground development the plant appears above the ground and lives like other flowering plants but still depends upon the host plant for water and nutrients. In about 30 days the witchweed plant blooms and begins producing seed. Individual witchweed plants produce from 50,000 to 500,000 almost microscopic seed. Bloom and the production of seed continue until the plant dies. Host plants attacked by the witchweed wilt severely, are stunted and become yellow in color. Eventually the leaves turn brown and the plant dies. The gross symptoms resemble those caused by a severe drought.

The catch crop method to eradicate the witchweed involves the repeated planting of crops which cause witchweed seed to germinate. Before the witchweed seed blooms and produces seed, both the catch crop and witchweed are destroyed. Although this method has been found effective an adaptation of catch cropping with chemical control of the witchweed was found to be more economical and essentially as effective. The current eradication program is based on this adaptation where commercial crops are grown on infested fields and the witchweed destroyed with 2,4-D before seed can be produced.

Witchweed is confined to a small agricultural area in North and South Carolina. Annual surveys are conducted in these States and in other corn, sorghum, and sugarcane producing States in search for new infestations and to determine the extent of local spread.

